Multinational Heterogeneity

and

Knowledge Diffusion

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Multinational Heterogeneity and Knowledge Diffusion

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Managementwetenschappen

Proefschrift

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door

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Contents

List of Tables

List of Figures

Acknowledgements

Zeer recentelijk is de houding in Nederland en andere (ontwikkelde) landen ten opzichte van buitenlandse investeerders wantrouwiger geworden. Onder andere door de invloed van buitenlandse *private equity funds* en zogenaamde durfkapitalisten die Nederlandse bedrijven opkopen, opsplitsen en daarna met forse winst doorverkopen, worden buitenlandse investeerders in toenemende mate met argusogen gevolgd. Ook naar aanleiding van de recente kredietcrisis en de daaruit voortvloeiende economische crisis wordt de roep om protectionisme steeds sterker. Deze ontwikkelingen zijn betreurenswaardig, want zoals de titel van dit proefschrift al doet vermoeden zijn er in potentie veel positieve effecten gemoeid met de investeringen van buitenlandse bedrijven in Nederland en andere landen. Ik beschouw het als een taak van de wetenschap om het publieke debat en de publieke opinie hierover beter te informeren, door op zoek te gaan naar de voorwaarden waaronder zulke positieve effecten plaatsvinden. Dit proefschrift is een poging hiertoe.

Om van de itentie tot een promotieonderzoek tot een daadwerkelijk proefschrift te komen heeft nogal wat om het lijf, en de afgelopen vier jaar hebben hier veel verschillende mensen op even zoveel verschillende manieren aan bijgedragen. Ik maak graag van deze gelegenheid gebruik om een aantal van hen te bedanken.

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Roger Smeets
22 maart 2009

Chapter 1

Introduction

1.1 Multinationals and Foreign Direct Investment

In 1996, the municipality of São José do Pinhais in Brazil attracted an investment by the French car manufacturer Renault, involving the creation of 1,500 new jobs. In return, Renault was offered a massive incentive package, including direct financial contributions up to \$ 300 million, a series of tax breaks, the donation of a 2.5 million square meter construction site, and a number of favorable loan conditions. In direct financial subsidies alone, this investment package thus came at a cost of \$ 200,000 per job created (Charlton, 2003). Blomström and Kokko (2003) document similar numbers for *inter alia* the attraction of Ford and Volkswagen subsidiaries in Portugal, at a cost of \$ 240,000 per job created.

These examples are by no means exceptions. On the contrary, they are part of a general development during the past two decades, in which countries world-wide have increasingly changed their investment regimes in favor of attracting investments of multinational enterprises – also known as Foreign Direct Investment (FDI) (UNCTAD; 2003, 2004). Inward FDI flows have increased all around the world during the past 25 years, as illustrated in Figure 1.1. Especially in the early 2000s a sharp increase in total inward FDI can be observed. Nonetheless, developed countries remain the most important benefactors of inward FDI and developing countries, notably on the African continent, keep lagging behind.

Looking at FDI as a share of total GDP in Figure 1.2, a similar pic-

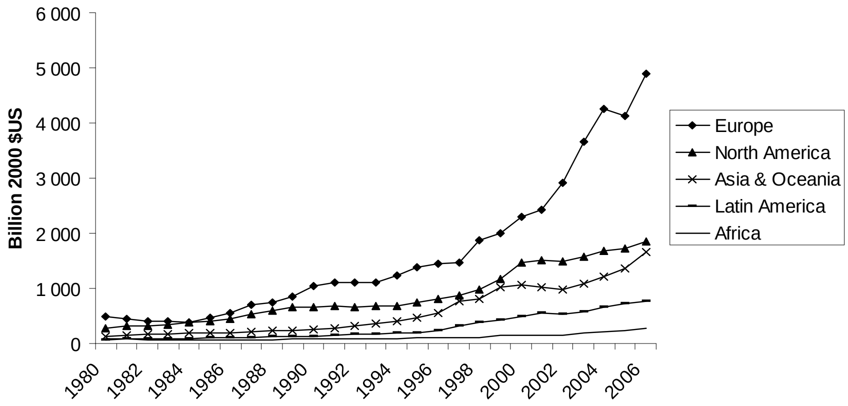


Figure 1.1: Inward FDI flows 1980-2006 (source: UNCTAD, 2007)

ture arises: Inward FDI shares have increased all over the world, but again developed regions deviate sharply from less developed ones. Countries in Latin America have been catching up somewhat during the early 2000s, but the African continent still remains underrepresented. As in Figure 1.1, we again observe a sharp increase in FDI shares during the early 2000s for most continents.

In sharp contrast, during the 1960s and 1970s many countries (home and host countries alike) inclined towards restricting multinational activities (Caves, 1974). In those years, many governments and the electorates they represented blamed multinationals (MNEs) for *inter alia* depleting scarce resources, exploiting host-country employees, and forming global monopolies to the disadvantage of consumers all over the world. Hence, over the course of the past four-and-a-half decade, governments' attitudes towards MNE activity or FDI have made a U-turn, with many countries competing to attract FDI into their territories nowadays (UNCTAD, 2004).

The question naturally arises what has caused this remarkable change. The answer to such a question is not likely to be found in one place, but the rise of endogenous growth theory in the early 1990s (Romer, 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1997) seems like a good starting point. Following the endogenous growth tradition, research on economic growth and development has increasingly focused on the role of knowledge and technology as the key driver of the economic growth process. This in-

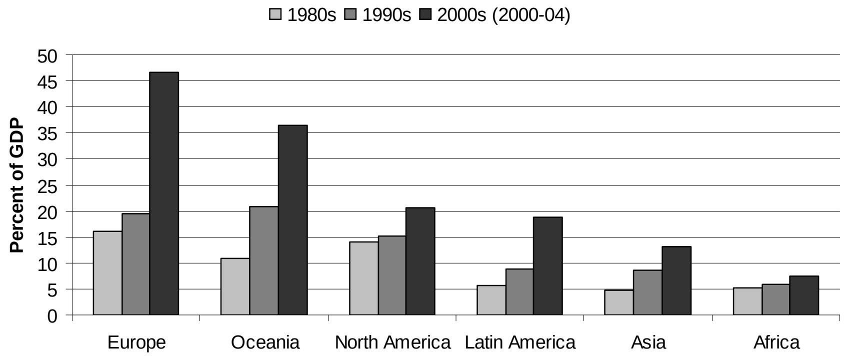


Figure 1.2: Inward FDI stocks as % of GDP 1980s-2000s (source: UNCTAD, 2007 and Summers, Heston and Aten, 2006)

terest in knowledge-based economics and growth has not been confined to academic circles: The Lisbon goals, laid down in 2000 by the members of the European Union (EU), testify of political awareness in this regard, as they were aimed at making the EU the most dynamic and competitive knowledge-based economy in the world. Simultaneously - and to some extent also as a consequence of increased political interest - businesses all around the world have put increasing efforts and resources into innovation and invention, as witnessed for example by the increases in business Research and Development (R&D) expenditures (OECD, 2007) and patent applications and grants (Jaffe and Trajtenberg, 2002).

A key feature of knowledge-based or innovation-based growth is the existence of knowledge spillovers (Romer, 1990). Simply stated, a knowledge spillover is the "leakage" of knowledge from the party that generated it, to a second party that is not directly involved in the generation of the knowledge (a more appropriate definition in the context of this thesis is provided in Chapter 2). Knowledge spillovers arise from the development and application of knowledge, since knowledge is essentially a public good. This implies that its use is both non-exclusive and non-rival: the application of an idea by person A does not prevent person B from applying that same idea as well (non-exclusivity). Moreover, once an idea is out there, the marginal cost of its replication are negligible relative to the costs of its conception (non-rivalry).

The fact that spillovers arise from the development and use of knowledge has two major consequences: first, it implies that some of the (economic) returns to the development of knowledge are not appropriable by the innovator or inventor. Second, the development of knowledge sets into motion a cumulative chain of events, in which individuals can easily (and more or less costlessly) build on existing knowledge to develop original ideas themselves. As such, knowledge spillovers are a crucial mechanism in knowledge-based economic growth and development.

Because of this importance of knowledge spillovers, a large amount of literature has investigated their existence, the conditions under which they arise, the mechanisms through which they occur and the (policy) implications that they entail. Two important contributors to this spillover literature are Adam Jaffe and Manuel Trajtenberg, who followed up on Zvi Grilliches' patent-project at the National Bureau of Economic Research (NBER) and constructed a database containing the universe of all patents granted by the United States Patent Office between 1960 and 1999, including all citations made by and to these patents. Using patent citations as a (noisy) indicator of knowledge spillovers, these authors demonstrated both the existence and the spatial restrictiveness of knowledge spillovers (Jaffe, Henderson and Trajtenberg, 1993).

Given the importance of geography for knowledge spillovers, scholars became increasingly interested in the mechanisms through which knowledge might spill over between countries. In a seminal study on such *international* knowledge spillovers, Coe and Helpman (1995) investigated the role of countries' imports in mediating international knowledge spillovers between countries. The empirical methodology differed markedly from the approach by Jaffe et al. (1993): instead of using patent citations as a measure of knowledge spillovers, Coe and Helpman (1995) investigated changes in country-level Total Factor Productivity (TFP) that resulted from increases in R&D-related imports from abroad, while controlling for other (observable) determinants of TFP. Their study demonstrated evidence of substantial import-mediated international knowledge spillovers, as witnessed by increases in TFP. Not only did this study spark a large empirical literature on international knowledge spillovers, it also laid down the basic empirical methodology on which much of the subsequent research would build.

1.2 Foreign Direct Investment and knowledge spillovers

After international trade had been shown to be an important mechanism for international knowledge spillovers, it was only a matter of time before scholars would focus their attention on the investments of MNEs as an alternative conduit for knowledge spillovers. In general, MNEs are large, innovative and R&D intensive companies (Markusen, 2002), which makes them very suitable as knowledge spillover mechanisms. Although earlier studies had already picked up the issue in a limited amount of countries (Caves, 1974) or in case studies (*cf.* Blomström and Kokko, 1998), large scale econometric investigations started to appear in the late 1990s and 2000s. Indeed, the (empirical) literature on knowledge spillovers from FDI has taken an enormous flight in recent years: a title-search on "spillovers from FDI" through google scholar yields over 115 unique articles in the field of business and economics at the time of writing, more than half of which have appeared after 2000.

Given the enormous increase in FDI activity and the often large amounts of money that governments spend on attracting it (as illustrated in Section 1.1), the obvious question is whether FDI indeed stimulates economic growth and development through knowledge spillovers. Unfortunately, despite the large amount of research on this topic, the academic literature has in general not been able to provide an unambiguous and satisfactory answer to this question. The extant literature paints a rather diffuse picture of the existence of knowledge spillovers from FDI: some studies have found evidence of positive spillovers (Javorcik, 2004a), some do not find any evidence (Van Pottelsberge de la Potterie and Lichtenberg, 1996)), and some even find evidence of negative spillovers (Aitken and Harrison, 1999). Regular literature surveys have confirmed this ambiguous state of affairs (Blomström and Kokko, 1998; Görg and Greenaway, 2004), as we will see in Chapter 2.

This general lack of empirical evidence on the knowledge spillover effects of FDI is rather disturbing, given the large sums of money that governments invest in attracting FDI. It could be argued that even if FDI does not generate knowledge spillovers, it at least entails other host-country benefits, such as the creation of new jobs, the generation of high-quality demand and supply for local industries, and signaling effects to potential other future MNE investors. Nonetheless, from a neoclassical economics standpoint, none of these factors warrant government FDI policy, as they do not reflect market failures that influence MNE behavior. For instance, the lack of new job creation might be the result of rigidities in the local labor market so that engaging in FDI policy in order to create new jobs is not the first-best solution in this case. The same holds for solving problems of inter-industry linkages, and the unattractiveness of countries or regions within countries due to regional underdevelopment.

On the contrary, the existence of knowledge spillovers from FDI *does* provide a legitimate reason for active FDI policy, since knowledge spillovers create a gap between the private returns to FDI on the one hand, and the social returns on the other. Specifically, if a MNE is considering to invest in a particular country, it only takes into account the returns it gets itself on that investment (the private return), and not the *additional* returns that the domestic economy may receive from it through knowledge spillovers (the social return). If (positive) knowledge spillovers indeed occur, this implies that the social return to FDI exceeds the private return. Accordingly, from a social planner's point of view, the MNE will in general invest too little, or not at all, because it does not take into account the social returns. In this case, active FDI policy which stimulates MNEs to engage in (more) investment is warranted, as it aims to bridge the gap between private and social returns. It is exactly because of this reason that the question whether or not knowledge spillovers from FDI exist is such an important issue, not only from a development perspective, but also from a policy point of view. So indeed, the ambiguity regarding the empirical evidence on knowledge spillover effects from FDI is rather disturbing. In a nutshell, the primary aim of this thesis is to resolve part of this ambiguity by considering the effect of an important but often ignored factor: heterogeneity between MNEs.

1.3 Thesis outline

Chapter 2 of this thesis will review some important recent contributions in the literature on knowledge spillovers from FDI and conclude *inter alia* that a number of these recent studies have started to acknowledge that MNEs and their FDIs differ from each other in many different respects. More importantly, these differences appear to significantly influence the occurrence and extent of knowledge spillovers from FDI, indicating that not taking them into account may be a source of the empirical ambiguity. Given the promising results that existing studies in this area have yielded so far, combined with the fact that there still are many unexplored dimensions of MNE heterogeneity, the rest of the thesis sets out to investigate several forms of MNE heterogeneity and their influence on the occurrence of knowledge diffusion.

Chapter 3 considers MNE heterogeneity in terms of their ownership share in foreign subsidiaries and extends a vertical linkages model by Markusen and Venables (1999) to include (a) differing degrees of multinational (MNE) ownership in their foreign affiliates and (b) knowledge diffusion, in addition to demand and supply linkages. It investigates the intra- and inter-industry effects of changes in MNE ownership on local firms' productivity via demand linkages, price effects and knowledge diffusion. Moreover, it also considers the mediating influence of national intellectual property rights protection (IPP). Given the ambiguous predictions of our model, we also investigate these issues empirically in a panel of 1,549 large firms spread out over 20 countries and 18 manufacturing industries during the period 2000-2005. We find that in countries with low IPP, the occurrence of intra-industry productivity effects is conditional on the cost structure of local firms. Moreover, inter-industry productivity effects are largely absent. Conversely, in countries with high IPP, both intra-industry and inter-industry productivity effects are high. Also, the relationship between productivity effects and MNE ownership varies both within and between industries, as well as between conditional and unconditional productivity effects.

In Chapter 4 we consider a second dimension of MNE heterogeneity, which is the market orientation of MNEs' foreign subsidiaries. Using data of US MNEs operating in 8 industries and 13 OECD countries during 1987-2003, we compare the productivity effects of local-market-oriented FDI (horizontal FDI) versus export-oriented FDI, with the latter being split into FDI oriented at the parent firm (in the home country) on the one hand (vertical FDI), and that at unaffiliated parties in third countries on the other hand (export platform FDI). Given the expected differential effects of regional integration on these different FDI types, we also consider their productivity effects within two regional agreements: The Canadian United States Free Trade Agreement (CUSFTA) and the European Union (EU). The results demonstrate some evidence of positive productivity effects of horizontal FDI that are larger than those of vertical FDI, but smaller than those of export-platform FDI. There are also substantial differences in effects of these FDI types between CUSFTA and the EU.

Finally, in Chapter 5 we follow up on a rather extensive literature on heterogeneity in FDI motives, particularly in technology exploiting versus technology seeking FDI. Many earlier studies have argued that technology exploiting FDI – FDI aimed at exploiting a technological or competitive advantage – is undertaken by high-productivity leader firms, and technology seeking FDI – FDI aimed at acquiring external knowledge or technology abroad – by low-productivity laggard firms. If this is indeed the case, the implication is that FDI with a technology exploiting motive is more likely to generate knowledge spillovers than technology seeking FDI. We start out by constructing a model to investigate optimal technology seeking strategies for leader and laggard firms. Our theoretical results indicate a large range of equilibria in which leader firms seek technology through Foreign Direct Investment (FDI) whereas laggard firms do so through exports. These results are mainly explained by the fact that laggard firms are not only less productive than leader firms, but also have less absorptive capacity and are less skilled in transferring technology across firm units. Confronting these theoretical results with case studies, recent econometric evidence and some original exploratory industry-level analysis, we find broad overall support. This finding thus implies that technology seeking FDI may just as well generate knowledge diffusion as technology exploiting FDI, given that both strategies are followed by leader firms. We continue by empirically testing this proposition, (again) using a new industry-level dataset of US MNEs' subsidiaries, active in 13 OECD countries over the period 1987-2003. Our results provide support to the fact that both technology exploiting and seeking FDI lead to knowledge diffusion.

Alongside, the thesis also aims to address two other issues that arise in the literature. The first is the important but often neglected distinction between knowledge spillovers on the one hand, and knowledge transfers on the other hand. A knowledge spillover, as explained above, is essentially an externality that arises from a market failure (i.e. the inability of the innovator or developer of the knowledge to fully appropriate its returns). Consequently, a knowledge spillover is an unintentional diffusion of knowledge which cannot be internalized by the diffusing party and therefore will result in less than optimal investment in knowledge. In this case, government policy intervention is warranted. In contrast, a knowledge transfer is an intentional diffusion of knowledge, often induced by an optimizing motive on behalf of the diffusing party. For example, a MNE's foreign affiliate may intentionally transfer knowledge or technology to its local suppliers in order to increase the quality of its inputs, so that eventually the quality of its own products are enhanced. In this case, there is no market failure as the MNE internalizes the knowledge diffusion. Consequently, there is also no ground for policy intervention. Throughout this thesis, we will stick to these two distinct definitions of knowledge spillovers and knowledge transfers. We will refer to both these processes collectively as knowledge diffusion.

Second, as will also become clear in Chapter 2, much of the literature on FDI knowledge spillovers has been empirical in nature. Theoretical contributions have been heavily underrepresented. In those instances where theory has been developed (Rodríguez-Clare, 1996; Glass and Saggi, 1998; Markusen and Venables, 1999; Müller and Schnitzer, 2006), knowledge spillovers are usually not the phenomenon of interest. Instead, many of these studies focus on *inter alia* competition effects, demand linkages, pecuniary spillovers or knowledge transfers. Therefore, next to shedding more light on the empirical relevance of MNE heterogeneity in the knowledge diffusion process, this thesis will also develop and adapt economic theory to provide a theoretical basis for these empirical exercises.

Chapter 2

Collecting the pieces of the FDI knowledge spillovers puzzle

2.1 Introduction

> "In the face of difficulties associated with capturing spillover effects and the multitude of factors that can influence the extent of spillovers in each economy, we caution researchers about drawing generalized conclusions about the existence of externalities associated with FDI [...]." (Javorcik and Spatareanu, 2005: p. 47)

As mentioned in Chapter 1, the past decade or so has witnessed a huge amount of research devoted to the investigation of knowledge spillovers from Foreign Direct Investment (FDI). At several points along the way, scholars have paused to review the current state of affairs and take stock of the evidence (Blomström and Kokko, 1998; Saggi, 2002; Görg and Greenaway, 2004). The verdict has usually been that we simply do not know. Explanations for this diversity in results have mainly focused on methodological and measurement issues (Görg and Strobl, 2001), but such an approach has recently been disputed (Lipsey and Sjöholm, 2005). Indeed, the empirical inconclusiveness has become so infamous that virtually every paper reviewed in this chapter starts with this observation as its main motivation.

The literature has been developing into several directions in order to come up with more detailed evidence that may help to explain the ambiguity in

[0] This chapter is an adapted version of Smeets (2008).

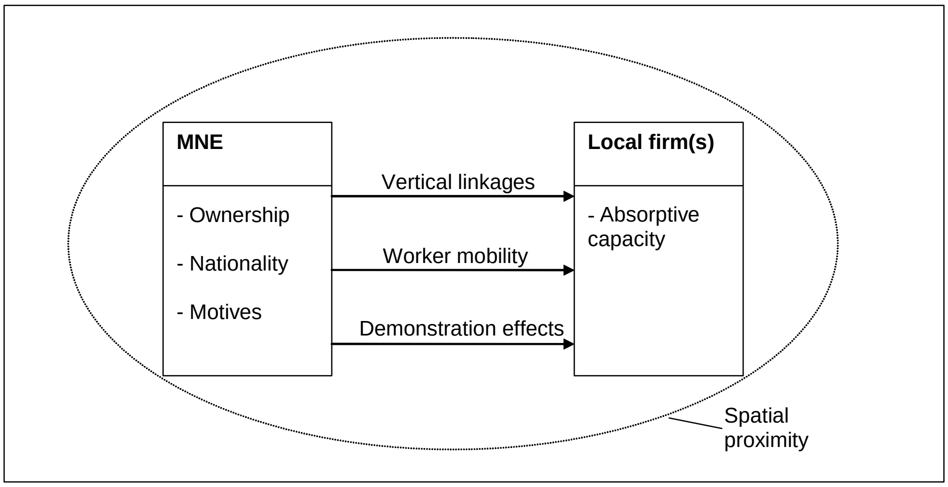


Figure 2.1: Schematic representation of the FDI knowledge spillover process

earlier literature. The aim of this chapter is to review these contributions, both theoretical as well as empirical, by structuring them around three common themes.[1] By doing so, we hope to provide some structure in a rapidly expanding field of research, while at the same time trying to identify which (combination of) approaches may yield promising research avenues. Moreover, more insight into the conditions under which knowledge spillovers from FDI are most likely to arise is of crucial importance for developing countries' governments seeking these benefits from FDI. Given the highly ambiguous evidence on the existence of knowledge spillovers from FDI so far, the large sums of money spent by governments to attract FDI (*cf.* Chapter 1) seem highly dubious. Obviously, inward FDI can generate other benefits such as additional employment increases and knowledge transfer through e.g. licenses, but none of these effects warrant active government policy as they take place through market mechanisms. Accordingly, obtaining more insight in the conditions under which knowledge spillovers from FDI occur (if they occur) is also highly relevant from a policy perspective.

[1]Methodological developments in the empirical FDI spillover literature, such as advances in productivity estimation or methods to deal with the endogeneity of FDI, are not considered in this chapter. However, they will be discussed when relevant in the subsequent chapters. Chapter 5 in Castellani and Zanfei (2006) contains a useful overview of recent methodological advances.

This chapter will be structured around Figure 2.1. This figure shows the schematic FDI knowledge spillover process, together with the different pieces of the puzzle that may affect this process. We start out in Section 2.3 by discussing research that has focused on the three arrows in the figure, which represent three knowledge spillover channels. We then proceed to review the evidence on the influence of mediating factors in Section 2.4, focusing mainly on absorptive capacity and spatial proximity, but also on intellectual property rights protection and the extent of host-country competition. Section 2.5 deals with the effect of FDI heterogeneity, and presents an overview of studies that have investigated the role of ownership structure, parent firm nationality and FDI motives as factors influencing the extent of knowledge spillovers. Section 2.6 concludes by pointing out how this thesis contributes to the existing literature, and in particular how it relates to some of the findings presented in this chapter. However, we first begin by briefly reiterating and illustrating the motivation for this thesis in Section 2.2.

2.2 Setting the stage

> "Much econometric work has been done in this area [*on knowledge spillovers from FDI*], but the results on the importance of spillovers are mixed at best." (Görg and Greenaway, 2004: p. 172)

The discussion in Chapter 1 suggests the following definition of a knowledge spillover in the context of this thesis: Knowledge created by one firm (i.e. a multinational enterprise - MNE), which is used by a second firm (i.e. a local host country firm), and where the latter does not (fully) compensate the former for this use (*cf.* Javorcik, 2004b: p. 607).[2] Note that this definition does not include any pecuniary spillovers (nominal gains resulting from the fact that quality increases are not fully reflected in prices) or competition effects (changes in market structure due to MNE entry). More importantly, it is also distinct from a knowledge transfer, which is purposeful or intended diffusion of knowledge from one firm to the other and as such represents no externality.

[2] The terms FDI and MNE will be used interchangeably in this chapter, as a FDI is essentially what distinguishes a multinational from a national firm (*cf.* Chapter 1). However, note that this does not imply that FDI is also the best proxy to measure MNE activity (Beugelsdijk et al., 2009)

The literature has distinguished three main channels along which knowledge may spill over from the MNE to a local firm (Saggi, 2006): demonstration effects, which means that local firms imitate or reverse engineer MNEs' products or practices; worker mobility from the MNE to the local firm, so that employees trained by the MNE can apply their knowledge in local firms; and vertical linkages (upstream and downstream), which means that the MNE spills over knowledge to its suppliers and customers (*cf.* Figure 2.1 above).

As was mentioned in Chapter 1, a lot of empirical research has tried to identify the direction, size and scope of knowledge spillovers from MNEs on local (host country) firms. A major problem for many of the econometric studies in this field is how to measure knowledge spillovers. The usual approach – following Coe and Helpman (1995 - *cf.* Chapter 1) – has been to assume that knowledge spillovers will mainly affect the receiving firm's productivity, so that they are often measured by changes in the receiving firms' productivity induced by MNE activity, while controlling for other (observable) determinants of productivity.[3]

The first major review of this empirical literature appeared in 1998 by Blomström and Kokko. Many of the studies reviewed in their paper are (multiple) case studies. One general finding is that most studies consider the effects of knowledge spillovers from MNEs through backward linkages, i.e. to supplier industries. Knowledge spillovers across the other channels are much less investigated. A second finding is that (multiple) case studies tend to find evidence of the existence of knowledge spillovers more often than econometric studies do.

This observation is also made by Görg and Strobl (2001), who conduct a meta-analysis of 21 econometric studies investigating knowledge spillover effects of FDI, in order to find out if the ambiguity in results can (partially) be explained by differences in research designs, methodology and data. In general, the econometric studies that are included in the analysis estimate models of the following form:

$$y_{ijt} = \beta_0 + \beta_1 FDI_{jt} + \beta_2 \mathbf{X}_{it} + \beta_3 \mathbf{Z}_{jt} + \varepsilon_{ijt} \tag{2.1}$$

where y_{ijt} is some measure of productivity of firm i active in sector j at time t, FDI is a measure of FDI presence, $\mathbf{X}$ is a vector of firm-level control

[3] Although this way of measuring knowledge spillovers may already raise a lot of questions and objections, these are not the focus of this chapter. Instead, we take standard empirical practice as given and proceed from there.

variables that are known to affect y (such as own investments in R&D and human capital) and $\mathbf{Z}$ is a vector of industry-level control variables (e.g. market concentration).[4]

Görg and Strobl's findings indicate that cross-section studies in general find more significant evidence of positive knowledge spillovers than panel studies do, that the exact measurement of FDI influences the results, and that there exists a publication bias in favor of studies finding evidence of significant positive knowledge spillovers.[5] However, Lipsey and Sjöholm (2005) demonstrate that when employing similar estimation techniques, on similar data over similar time-periods but for different countries, results tend to diverge. This leads them to conclude that heterogeneity in host-country factors are the most likely source of the inconclusiveness in empirical research (*cf.* Section 2.4 below).

The most recent comprehensive survey of empirical research on knowledge spillovers from FDI is by Görg and Greenaway (2004). These authors survey no less than 40 econometric studies, mainly at the microeconomic level of analysis. Their review clearly indicates that the empirical evidence is ambiguous at best, with 20 cases finding evidence of positive spillovers, about 17 cases finding insignificant results and 8 cases finding evidence of significant negative knowledge spillovers.[6] The studies that they review cover a variety of different periods and countries, and applied research designs are both cross-sectional and panel.[7]

[4] A couple of notes apply to model (2.1). First, different studies use different measures of productivity: Some look at total factor productivity while others consider labor productivity, making comparisons more difficult. Second, the endogeneity issue of FDI in model (2.1) (i.e. FDI may be attracted to more productive countries, regions or sectors, reversing the causal mechanism) is not always properly taken care of, which could bias the estimation results.

[5] The fact that cross-section studies tend to find more evidence of knowledge spillovers than panel studies could indicate that unobserved firm heterogeneity is interfering with the results in the studies of the former type.

[6] These add up to more than 40 cases because some studies contain more than one empirical test.

[7] Keller (2004) provides an excellent survey of the wider literature on international technology diffusion, including knowledge spillovers from FDI.

2.3 Opening the black box of FDI knowledge spillover channels

> "One of the drawbacks of these [*empirical FDI spillover*] studies is that they treat the specific mechanisms by which the spillovers are supposed to occur as a 'black box'." (Görg and Strobl, 2005: p. 695)

As became apparent in the review of Blomström and Kokko (1998), apart from (case) studies investigating knowledge spillovers from FDI through backward linkages, none of the other spillover channels (the arrows in Figure 2.1) have been explicitly considered in the empirical literature. Indeed, the general empirical model as specified in (2.1) is the one mostly encountered in econometric tests of knowledge spillovers from FDI. As has been argued by other authors (e.g. Görg and Strobl, 2005), such an empirical specification completely disregards the different knowledge spillover channels. As such, it could very well be that FDI in (2.1) picks up a net effect of FDI, e.g. including adverse competition effects (Aitken and Harrison, 1999).[8] Consequently, empirical research has increasingly been trying to take into account the different spillover channels explicitly.

2.3.1 Vertical linkages

Many of the studies opening the black box of knowledge spillovers from FDI have focused on knowledge spillovers through vertical linkages (*cf.* Hoekman and Javorcik, 2006. See Lin and Saggi, 2005 and Saggi, 2006 for brief reviews). When determining knowledge spillovers through backward linkages we have to distinguish between *knowledge transfer*, i.e. purposeful knowledge transmission from the MNE to its suppliers or customers, versus *knowledge spillovers*, i.e. the pure knowledge externality. Most likely, the latter will be a consequence of the former, since the local supplier or customer firm can exploit the knowledge it has received from the MNE in its (vertical) relationships with other firms.

[8] Of course, the existence of adverse competition effects assumes that the MNE goes abroad mainly to produce for the local market. I.e. it assumes that the market orientation of FDI is mainly local instead of export-oriented, in which case adverse competition effect is less likely to occur, or in any case will be less severe (*cf.* Protsenko, 2003 and Chapter 4 of this thesis).

Two relatively early theoretical contributions in this field are Rodríguez-Clare (1996) and Markusen and Venables (1999). Rodríguez-Clare focuses on input demand-effects of MNEs: He constructs a model with monopolistic competition in the intermediates sector, which nationals firms and MNEs use as inputs in their final goods production. He further assumes that MNEs' final goods are more complex (i.e. require a larger variety of inputs) and that all firms have love-of-variety for inputs. Accordingly, the entry of a MNE induces an increased demand for intermediate inputs, which establishes the backward linkage. Due to monopolistic competition in this sector, the variety of available inputs produced increases, and final goods producers benefit due to the love-of-variety for inputs, which establishes the forward linkage effect.[9] The Markusen and Venables model (discussed in greater detail in the next chapter) has a similar setup. However, they explicitly consider the intra-industry competition effect (next to the linkage effect) that a MNE induces upon entry, whereas this is effectively absent in Rodríguez-Clare, who considers situations in which MNEs are the only firms producing in one of the two countries. These two studies thus only look at pecuniary spillovers and competition effects of FDI, not at knowledge spillover effects.

Lin and Saggi (2007) do explicitly consider vertical technology transfer (VTT) through backward linkages, i.e. from MNEs to their local suppliers. They assume that upon entry, a MNE can negotiate an exclusivity contract with a number of local suppliers, implying that these suppliers are not allowed to supply any of the local firms anymore. Only then will the MNE engage in VTT. Yet applying our understanding of knowledge spillovers from FDI through vertical linkages, this model does not consider knowledge spillovers either.

Despite this apparent lack of theoretical research on pure knowledge spillovers, there exist quite a number of empirical studies in this particular area. In general, all these studies estimate a modified version of model (2.1):

[9] Hence, the forward linkage is conditional on the backward linkage. The extent to which the backward linkage takes place largely depends on the input demand of the MNEs, relative to that of the domestic firms they displace. This depends on the fraction of inputs that is obtained from the host country (instead of imported from the home country), which in turn depends on the complexity of the final good, the ease of communication between HQ and subsidiary, and the degree of similarity between the host and home country.

$$y_{ijt} = \beta_0 + \beta_1 FDI_{jt} + \beta_2 \Sigma_{k \neq j}(\alpha^O_{jkt} \cdot FDI_{kt}) + \beta_3 \Sigma_{k \neq j}(\alpha^I_{jkt} \cdot FDI_{kt}) + \beta_4 \mathbf{X}_{it} + \beta_5 \mathbf{Z}_{jt} + \varepsilon_{ijt} \quad (2.2)$$

where y, $\mathbf{X}$ and $\mathbf{Z}$ are defined as in (2.1), α^O_{jk} is the share of output sold by inudstry j to industry k, and α^I_{jk} is the share of inputs bought by industry j from industry k. Furthermore, i indexes firms, j (k) indexes industry and t indexes time.[10] In this model, β_2 thus captures the effect of FDI in sector k on the productivity of firm i in sector j , weighted by the share of output flowing from sector j to k, i.e. β_2 captures backward linkages. By similar reasoning, β_3 captures forward linkages. β_1 measures the effect of FDI in firm i's own sector, which can be interpreted *inter alia* as a demonstration effect (*cf.* Section 2.3.3 below).

Javorcik (2004a) analyzes knowledge spillovers from MNEs through backward and forward linkages in a panel of approximately 4000 Lithuanian firms. She finds evidence of positive knowledge spillovers through backward linkages, but not through forward linkages. Javorcik and Spatareanu (2008) also find evidence of positive knowledge spillovers through backward linkages, but only from MNEs that share ownership with local firms. Kugler (2006) analyzes inter-industry spillovers from FDI for eight Colombian manufacturing sectors, and finds strong and robust evidence of backward linkages, whereas forward linkages are largely absent. A similar result is obtained by Bwalya (2006) for a sample of 125 Zambian manufacturing firms. Schoors and van der Tol (2002) also find evidence of positive knowledge spillovers through backward linkages in Hungary, but negative spillovers through forward linkages. Moreover, they find that these intersectoral effects are statistically more important than the intrasectoral effect (β_1).

However, it is questionable whether these empirical studies actually measure knowledge spillovers and not knowledge transfer. Indeed, in a study of over 100,000 Indonesian manufacturing establishments, Blalock and Gertler (2007) find evidence of local firm productivity increases through vertical linkages with MNEs, which they motivate by explicitly referring to knowledge transfers rather than spillovers from the MNE. Javorcik and Spatareanu (2005) and Javorcik (2008) use survey data on the perceptions of managers in

[10] Although here we subscript the α's with t as well, most studies do not have time series data on input-output matrices, and instead use α's for one fixed year. Blalock and Gertler (2007) is an exception.

local Latvian and Czech firms and find that intentional MNE assistance is an important factor influencing these local firms' productivity. Pack and Saggi (2001) provide a theoretical treatment of vertical technology transfer. These studies clearly demonstrate the importance of knowledge transfer vis-à-vis knowledge spillovers.

2.3.2 Worker mobility

A second channel through which knowledge spillovers can flow from MNEs to local host country firms is through labor turnover. The line of reasoning here is that the MNE is likely to provide (part of its) host country workforce with a higher degree of training, education and valuable working experience than the average local firm. If (part of) this workforce at some point in time chooses to work in a local firm, or start up its own local company, it can apply knowledge acquired in the MNE's subsidiary to the local firm's benefit. Since the MNE is not compensated for this, it indeed constitutes a knowledge spillover as defined above.

Fosfuri, Motta and Ronde (2001) were one of the first to formally model this channel of MNE knowledge spillovers. They construct a model in which a firm has to choose between FDI and exports to serve the foreign market, and needs to train a host country worker if it chooses the former. When training is completed, both the MNE and a local firm can make a bid to acquire the services of the trained local worker. Knowledge spillovers occur if the local firm makes the higher bid. Such a situation is most likely to happen if market competition is low and knowledge is easily transferable. The intuition behind this qualification is that in this case there is a lot to gain for the local firm by obtaining the knowledge, whereas the costs of training an additional worker for the MNE are relatively low. Markusen and Trofimenko (2009) model worker mobility as a channel for knowledge spillovers in a general equilibrium setting, in which they model the development of wages paid by firms that attract experts from MNEs.

In empirical research on knowledge spillovers through worker mobility, two models are generally encountered. The first one is a rather straightforward extension of (2.1) and looks as follows:

$$y_{ijt} = \beta_0 + \beta_1 S_{it}^M + \beta_2 \mathbf{X}_{it} + \beta_3 \mathbf{Z}_{jt} + \varepsilon_{it} \tag{2.3}$$

where i, j and t again index firm, sector and time respectively. In this case,

S^M denotes some measure of the presence of foreign workers, i.e. workers that were previously employed by a MNE's subsidiary. If knowledge spillovers diffuse through worker mobility, we would expect β_1 to be positive.

A second empirical specification analyzes knowledge spillovers through worker mobility at the individual level, by looking at wages. The general specification in this case is:

$$w_{ijt} = \beta_0 + \beta_1 S^M_{jt} + \beta_2 \mathbf{X}_{it} + \beta_3 \mathbf{Z}_{jt} + \varepsilon_{ijt} \tag{2.4}$$

where i, j and t index individual, firm and time respectively. w denotes the (log of) the individual wage level. The underlying assumption is that wages are strongly correlated with (marginal) productivity. Hence, positive knowledge spillovers through worker mobility imply that β_1 is positive.

Markusen and Trofimenko (2009) empirically test their model predictions along the lines of the model in (2.4), using plant-level data on a sample of 304 Colombian manufacturing establishments employing ten workers or more. Their empirical results largely support their model, showing that hiring foreign experts increases the (real) wages of the hiring plant. This effect is both instantaneous (i.e. it occurs during the period of hiring) and persistent (it remains even after the foreign expert has left the plant).

Other papers empirically testing knowledge spillovers through worker mobility are scant. Görg and Strobl (2005) estimate a model similar to the one in (2.3) in a panel of 228 Ghanaian manufacturing firms. Their results indicate that an owner's (of a local firm) previous experience with a MNE indeed increases the local firm's productivity, but only if that MNE is operating in the same sector as the local firm. Moreover, having an owner that also received explicit training in the MNE does not contribute significantly to firm-level productivity.[11] Poole (2008) analyzes knowledge spillovers through worker mobility at the worker-level, using data on Brazilian formal-sector workers in a model similar to the one in (2.4). She finds that an increase in S^M increases wages, indicating that knowledge is spilling over from former MNEs' employees to national firms. Hale and Long (2006) investigate spillovers from FDI in a sample of 1500 firms in five Chinese cities. These authors also find evidence that an increase in S^M increases firm productivity.

[11] Of course the question arises to what extent this result reflects the more general situation in which any foreign employee (not just the owner) hired by a local firm can spill over knowledge.

2.3.3 Demonstration effects

Various definitions of demonstration effects can be found in the literature (*cf.* Cheung and Lin, 2004; Moran, Graham and Blomström, 2005). Here, we follow Saggi (2002) who defines demonstration effects as occurring through the imitation and reverse engineering of MNE's products and practices by local (host country) firms. This definition largely fits our understanding of knowledge spillovers.

Many of the studies reviewed by Görg and Strobl (2001) and Görg and Greenaway (2004) implicitly deal with knowledge spillovers through demonstration effects, since the majority is looking for horizontal (i.e. intra-industry) knowledge spillovers. By (Saggi's) definition, demonstration effects will mainly occur through these horizontal spillovers. Hence, the general empirical specification looks like the one in (2.1). As discussed in Section 2.2, these studies yield very conflicting empirical results.

One problem in this respect is that none of these studies actually hypothesize or specify in what way demonstration effects take place. A study by Cheung and Lin (2004) sheds a bit more light on this issue. They study the effect of FDI presence on patent applications in 26 provinces in China, and distinguish between three types of patents: Invention patents (concerning new technical solutions), utility patents (new technical solutions relating to the shape or structure of a product) and design patents (new design of shape or pattern). Their results show that increased FDI in a province has a positive effect mainly on design patents. Since the content of such patents is most easily copied, they interpret this as evidence of demonstration effects. Moreover, this effect is strongest in the coastal region, where the amount of inward FDI is highest as well. The paper by Hale and Long (2006) discussed in the previous section also finds some circumstantial evidence of demonstration effects through network externalities.

2.3.4 Taking stock & discussion

The work on opening the black box of knowledge spillovers from FDI seems a promising strand of research. Besides obtaining more detailed insights in the exact mechanisms along which knowledge spillovers may come about, the empirical results also seem to agree much more with each other than previous black box research, as witnessed by Table 2.1. Nonetheless, a few concerns remain.

Table 2.1: Spillover channels and FDI knowledge spillovers - Empirical studies

Spillover Channel	**Study**	**Sample**	**Results**
Vertical linkages	Javorcik (2004a)	4000 firms in Lithuania: 1996-2000	Positive effects through backward linkages No effects through forward linkages
	Javorcik & Spatareanu (2008)	All firms in Romania: 1998-2003	Positive effects through backward linkages
	Kugler (2006)	All manufacturing firms in Colombia: 1974-1998	Positive effects through backward linkages No effects through forward linkages
	Bwalya (2006)	125 Zambian manufacturing firms: 1993-1995	Positive effects through backward linkages No effects through forward linkages
	Schoors & Van der Tol (2001)	1084 firms in Hungary: 1997-1998	Positive effects through backward linkages Negative effects through forward linkages
Worker mobility	Markusen & Trofimenko (2009)	All manufacturing establishments in Colombia: 1977-1991	Positive
	Görg and Strobl (2005)	228 firms in Ghana: 1991-1997	Positive
	Poole (2006)	Formal sector workers in Brazil: 1996-2001	Positive
	Hale and Long (2006)	1500 firms in China: 2000	Positive
Demonstration effects	Cheung and Lin (2004)	26 provinces in China: 1995-2000	Positive
	Hale and Long (2006)	1500 firms in China: 2000	Positive

First, following our understanding of knowledge spillovers, theoretical work on knowledge spillovers through vertical linkages is virtually absent. Most studies consider only pecuniary spillovers, or knowledge transfer. Contributions in this field are much needed. As far as the empirical literature in this field is concerned, it is not always clear that they are actually measuring knowledge spillovers instead of knowledge transfers. Although the distinction may seem irrelevant from the host-country's perspective, the policy implications in either of the two cases diverge heavily (Blalock and Gertler, 2005; 2007). If anything, empirical studies in this field should at least be aware of this potential bias.

Second, much of the inferred knowledge spillover effects in the worker mobility literature are based on wage developments, which assumes a very strong relationship between (marginal) worker productivity and wages. To the extent that workers are able to collectively bargain over their wages, developments in wage structure may be a misleading indicator of productivity and knowledge spillovers. Moreover, to the extent that local firms are explicitly hiring and paying former MNE employees to provide training to their own employees, any subsequent productivity effect cannot be considered a knowledge spillover according to the definition that we apply in this thesis (*cf.* Castellani and Zanfei, 2006: Ch. 5). Hence, in this area too, scholars should at the least be more aware of this issue.

Finally, research regarding the existence of demonstration effects is less developed, that is, without considering the extensive black box literature on intra-industry knowledge spillovers from FDI. There are no real theoretical contributions in this field, conceptually nor formally, and definitions of demonstration effects vary. This makes an empirical assessment rather difficult, since it is not clear *ex ante* through which mechanisms such demonstration effects should take place. Therefore, more theorizing or conceptualization on this topic seems necessary before anything substantial can be expected from empirical research.

2.4 Mediating factors

> "An explanation [*for the diverse conclusions in FDI spillover studies*] that seems plausible is that countries and firms within countries might differ in their ability to benefit from the presence of foreign-owned firms and their superior technology." (Lipsey

and Sjöholm, 2005: p. 23)

A strand of literature, that has been around for some time now, has tried to identify those mediating factors that are required for an effective transmission of knowledge spillovers. Such factors can thus be seen as necessary conditions for knowledge spillover potential to turn into actual knowledge spillovers. As such, absence (or presence) of these factors may crucially influence observed knowledge spillovers, and not taking them into account can bias empirical results.

Usually, these factors pertain either to the receiving party (i.e. the host country, sector, region or firm) or to the relationship between the parties involved. Probably the most well-known concepts in this field are those of absorptive capacity and spatial proximity. We will discuss these in the following two subsections, followed by a brief review of some other mediating factors.

2.4.1 Absorptive capacity & backwardness

In the general literature on the role of a firm's, region's, industry's or country's own technology or productivity in capturing knowledge spillovers, two alternative views exist. On the one hand, there are those that claim that increased (technological) *backwardness* should enhance knowledge spillovers, since the potential for knowledge spillovers is large in that case (Findlay, 1978; Wang and Blomström, 1992). On the other hand, it has been claimed that firms need some minimum amount of *absorptive capacity* to be able to capture knowledge spillovers (Cohen and Levinthal, 1989; 1990; Glass and Saggi, 1998). Such absorptive capacity is created by investments in R&D or human capital, and provides a basis of (fundamental) knowledge or technology, necessary to assimilate and exploit external knowledge.

Some early contributors in this field (implicitly) suggest a complementary relationship between backwardness (BW) and absorptive capacity (AC). Findlay (1978) argues that "[the] greater the backlog of available opportunities [...] the greater the pressure of change within the backward region [...]. Of course, the disparity must not be too wide for the thesis to hold" (p. 2). This final remark hints at the importance of some minimum level of AC. Abramovitz (1986) states that "[...] a country's potential for rapid growth is strong not when it is backward without qualification, but rather when it is technologically backward but socially advanced" (p. 388). Hence, he conditions the benefits of BW on the presence of social capabilities. Although he also states that such capabilities are hard to identify, again this hints at the importance of some form of AC.

In the empirical literature on knowledge spillovers from FDI, the following general model is encountered, although a lot of variations on this specification exist:

$$y_{ijt} = \beta_0 + \beta_1 FDI_{jt} AC_{it} + \beta_2 FDI_{jt} BW_{it} + \beta_3 \mathbf{X}_{it} + \beta_4 \mathbf{Z}_{jt} + \varepsilon_{ijt} \tag{2.5}$$

where AC and BW are measures of absorptive capacity and backwardness, respectively. Note that AC and BW are not always included simultaneously in the model.

Griffith, Redding and Simpson (2002) only consider the mediating effect of BW on knowledge spillovers from FDI in a sample of 13,000 UK manufacturing establishments They measure BW as frontier level TFP relative to local establishment i's TFP. Frontier level TFP is defined either as the highest establishment level TFP at the 4-digit industry level at time t, or as the average of the top 3 establishment's with the highest TFP. Hence, an increase in BW implies that establishment i is becoming more backward. Their β_2 in model (2.5) is positive and significant for both measures of BW, illustrating the importance of backwardness. Griffith, Redding and Van Reenen (2004) use a similar measure of BW at the country-industry level, but also consider the effect of AC. Their empirical results demonstrate that both BW and AC show up positively and significantly, indicating their simultaneous importance.

Another study applying a similar measure of BW is Castellani and Zanfei (2003), who define BW as the ratio of the average TFP level of foreign firms in 2-digit industry j, over firm i's TFP level. AC is measured as firm i's TFP level. Estimating a model as in (2.5) they find that only β_2 shows up positively and significantly.

In a study of 7,516 UK companies, Girma (2005) specifically investigates the role of AC in capturing knowledge spillovers from FDI. His measure of AC is a firm's TFP level at time $t-1$, relative to the maximum level of TFP in the firm's 4-digit level industry in that period. So in fact, it is more or less the inverse of the BW measure used in the three studies above. He specifically investigates non-linear effects of AC in interaction with FDI, *inter alia* by applying threshold regression analysis, and finds an inverted U-shaped effect: The knowledge spillover mediating effect of AC is maximized at intermediate levels of AC. This finding is explained by the fact that firms with very low AC are not able to absorb knowledge spillovers, whereas those with very high AC are too close to the technological frontier to benefit from knowledge spillovers. This suggests an interior optimum value of AC. However, using the same measure of absorptive capacity in a panel of British firms in the electronics and engineering industries, Girma and Görg (2007) instead find evidence of a U-shaped effect of absorptive capacity. This finding is rationalized by referring to the interaction of positive knowledge spillover effects and negative competition effects from FDI: At low levels of AC local firms experience neither, but as AC starts to increase, first only the negative competition effect will start to work. This intially depresses productivity. Only after some threshold AC level has been reached will the positive knowledge spillover effect start to work, and gradually outweigh the negative competition effect. Grünfeld (2006) corroborates this result theoretically.[12]

What, then, is the general conclusion regarding the mediating effect of BW and AC on knowledge spillovers from FDI? Comparing studies is difficult, because they use different empirical specifications and employ different measures of BW and AC. Moreover, many of these studies disregard the relation between backwardness and absorptive capacity.

An exception is Castellani and Zanfei (2003), who explicitly investigate the correlation between BW and AC at the industry level. Recall that their definition of BW is the ratio of the average TFP level of foreign firms in 2-digit industry j, over firm i's TFP level, whereas AC is measured as firm i's TFP level. Hence, AC is the denominator of BW. Not surprisingly, they find an overall negative relationship between BW and AC. Unfortunately, when running their empirical regressions they nonetheless ignore this relationship. In terms of the model in (2.5), this implies that the marginal effect of AC_{it} on $y_{ijt,}$ is given by:

$$\frac{dy_{ijt}}{dAC_{it}} = FDI_{jt}\left(\beta_1 + \beta_2 \frac{dBW_{it}}{dAC_{it}}\right) \tag{2.6}$$

This total derivative of y_{ijt} with respect to AC_{it} shows that the marginal

[12] A final noteworthy study is by Falvey, Foster and Greenaway (2007) who consider the simultaneous effect of BW and AC at the country level. However, they essentially estimate an empirical growth model and focus on trade-related knowledge spillovers. Generally, their results hint at the importance of BW over AC, although the results tend to vary with the preferred specification and estimation method.

effect of AC_{it} on y_{ijt} has both a direct component (β_1) as well as an indirect component (through its effect on BW). Given that AC is the denominator of BW, this implies that an increase in AC will work to reduce BW (i.e. $dBW_{it}/dAC_{it} < 0$). Hence even if the direct effect of AC_{it} (β_1) is positive, its indirect effect through BW ($\beta_2 \cdot [dBW_{it}/dAC_{it}]$) is clearly negative (for $\beta_2 > 0$).

The empirical disregard for the relationship between BW and AC applies to all studies that simultaneously include measures of both. In general, if BW is measured in terms of relative TFP levels and AC is measured in terms of absolute TFP levels, R&D stocks, human capital, and so forth, the knowledge production function literature (Griliches, 1979) suggests that a relationship probably exists between BW and AC, which should be taken into account empirically.

A simple way out of this problem is to use the AC measure of Girma (2005) and Girma and Görg (2007), who measure absorptive capacity as the inverse of backwardness: an increase in backwardness implies a simultaneous and proportional decrease in absorptive capacity and vice versa. Absorptive capacity as a relative concept also seems to make sense intuitively: as Castellani and Zanfei (2003) show, high absolute levels of TFP (AC) may still be accompanied by large technology gaps if foreign firms in the sector also exhibit extremely high (average) TFP levels. In such a situation absolute measures of AC probably do not capture actual absorptive capacity.

Finally, some studies estimate BW relative to frontier-level TFP, where the frontier is the highest (average) TFP level of the relevant sector in general. Because knowledge spillovers from FDI are investigated, however, it seems more appropriate to consider the TFP of the relevant multinational enterprises as the frontier.

2.4.2 Spatial proximity

A by now well-established empirical literature has been arguing that spatial proximity (i.e. being geographically close to the MNE) is an important condition for capturing knowledge spillovers from FDI. Reasons for the alleged relevance of geography can be traced back to the individual knowledge spillover channels dealt with in Section 2.3. It has been argued (e.g. Girma and Wakelin, 2007) that many of these channels have a clear spatial component: e.g. the limited geographical mobility of labor implies that knowledge spillovers through worker mobility are strongly localized.

Table 2.2: Mediating factors and FDI knowledge spillovers - Empirical studies

Factor	**Study**	**Sample**	**Results**
Absorptive capacity/ Backwardness	Griffith, Redding and van Reenen (2002)	15,000 manufacturing firms in UK: 1980-1992	Backwardness: Positive
	Castellani and Zanfei (2003)	3,932 firms in France, Italy, and Spain: 1992-1997	Backwardeness: Positive Absorptive Capacity: No effect
	Girma (2005)	7,516 firms in UK: 1989-1999	Absorptive Capacity: Inverted U-shaped effect
	Peri and Urban (2006)	40,000 firms in Italy: 1993-1999 800 firms in Germany: 1993-1999	Backwardness: Positive
	Girma and Görg (2007)	2,100 electronic firms in UK: 1980-1992 4,800 engineering firms in UK: 1980-1992	Absorptive Capacity:U-shaped effect
Geographic proximity	Barrios, Bertinelli and Strobl (2006)	338 plants in 26 counties in Ireland: 1983-1998	Positive
	Girma and Wakelin (2007)	11,000 plants and 10 NUTS in 1 region in UK: 1980-1992	Positive
	Nicolini and Resmini (2007)	26 sectors and 30 NUTS in 2 regions Bulgaria, Poland and Romania: 1998-2003	Positive

Theoretical work on the spatial dimension of knowledge spillovers from FDI is sparse. Martin and Ottaviano (1999) and Baldwin, Martin, and Ottaviano (2001) introduce spatially bounded knowledge spillovers in a new economic geography setting. Combining a two-region new economic geography model (Krugman, 1991) with a Romerian-type endogenous growth model (Romer, 1990), they investigate the influence of spatially bounded knowledge spillovers on growth rates in the two regions. Their results show that geography (firm location) matters only for growth when knowledge spillovers are spatially bounded. If spillovers are global, both regions grow at similar rates in long-run equilibrium. Knowledge spillovers from multinational enterprises are absent in these frameworks.

Jaffe et al. (1993) and Jaffe and Trajtenberg (2002) have made seminal empirical contributions on the spatial dimension of knowledge spillovers (not necessarily from FDI). By looking at patent citations while controlling for the fact that innovation activity itself may be localized, they show that knowledge spillovers are localized at various levels (country, state, and metropolitan statistical areas). Audretsch and Feldman (1996) show that geographic clustering of innovative activity is more pronounced in knowledge-intensive industries.

Keller (2002) attaches a number to the spatial decay of knowledge spillovers from R&D in the group of five large industrial countries to nine European countries. He finds the "half-life" of knowledge spillovers (i.e. the distance it takes for half of total knowledge spillovers to be eroded) to be about 1,200 kilometers. Bottazi and Peri (2003) find an even stronger localization effect of knowledge spillovers in the EU-15, where the effect of regional R&D (inputs) on the number of patents (outputs) vanishes beyond 300 kilometers.

Although a wide body of literature exists on the spatial dimension of knowledge spillovers, specific applications to knowledge spillovers from FDI are still relatively limited. The empirical specification in (2.1) can be extended to incorporate a regional effect:

$$y_{irt} = \beta_0 + \beta_1 FDI_{rt} + \beta_2 \left[\mathbf{w}_s \cdot \mathbf{FDI}_{st}\right] + \beta_3 \mathbf{X}_{it} + \beta_4 \mathbf{Z}_{rt} + \varepsilon_{irt} \text{ s.t. } r \neq s \quad (2.7)$$

where r and s index region. Hence, β_1 measures the effect of FDI within the same region as firm i, whereas β_2 measures the effect of FDI located in other regions than firm i. Sometimes, the effect of this latter type of FDI is weighted by a matrix $\mathbf{w}$ incorporating the distance between region r and s. $\mathbf{Z}_{rt}$ is a vector with region-specific characteristics (e.g. region size in terms of population or GDP). If knowledge spillovers from FDI are spatially bounded, we would expect β_1 to be positive, and β_2 to be insignificant.

Barrios, Bertinelli, and Strobl (2006) construct an index that measures the extent to which local firms and multinational enterprises coagglomerate within counties in Ireland. They find that productivity effects of FDI are positive and significant only in counties that show a positive and significant degree of coaglommeration.

Girma and Wakelin (2007) distinguish 10 regions that roughly correspond to the Nomenclature of Territorial Units for Statistics 1 (NUTS 1) classification in the European Union.[13] Their results indicate that the productivity of domestic plants is positively affected by FDI within but not outside the region (both weighted and unweighted by distance).

Nicolini and Resmini (2007) document positive knowledge spillover effects on regional (domestic) TFP from multinational enterprises located in the same region and negative spillover effects from the presence of multinational enterprise in other regions.

2.4.3 Intellectual Property Rights

Two offsetting effects make the relation between the strength of intellectual property rights and the extent of knowledge spillovers from FDI ambiguous. Strong intellectual property rights induce multinational enterprises to transfer more and higher quality knowledge to their subsidiaries, thereby increasing knowledge spillover potential, but they make it more difficult to capture knowledge spillovers (for example, through imitation). The net effect is not clear *a priori*.

Markusen (2001) studies the effect of changes in intellectual property rights protection on welfare and spillovers in a host developing country. He finds that if the multinational enterprise cannot write an enforceable contract with a local agent, increased intellectual property right protection makes spillovers less likely. Glass and Saggi (2002) show that increased intellectual property right protection in developing countries has a similar effect on multinational enterprises and national firms in industrial countries, so that FDI does not become relatively more attractive.

[13] NUTS provides a single uniform breakdown of territorial units for the production of regional statistics for the European Union. NUTS 1 denotes the broadest level, NUTS 3 denotes the most disaggregated one.

Most empirical research considers only the effect of intellectual property rights on the volume or composition of FDI or on the incentives for intrafirm technology transfer. Javorcik (2004a) investigates the effect of intellectual property rights on the composition of inward FDI in the Russian Federation and five countries in Central and Eastern Europe. Branstetter, Fisman, and Foley (2006) analyze the effect of intellectual property rights protection on technology transfer from 1,000 U.S. multinational enterprises to about 5,000 of their foreign affiliates in 16 developing countries. The implication of their results for FDI knowledge spillovers are not clear.

Feinberg and Majumdar (2001) analyze the knowledge spillover effects of FDI in a sample of 65 domestic firms and 30 multinational enterprises operating in the pharmaceuticals sector in India during the 1980s and early 1990s, when intellectual property rights protection in the sector was reportedly weak. They find virtually no evidence of knowledge spillovers. This finding could be considered circumstantial evidence that weak intellectual property rights protection does not stimulate knowledge spillovers from FDI. Indeed, Allred and Park (2007) conclude that there exists an optimal and positive degree of intellectual property rights protection that stimulates diffusion of knowledge from multinational enterprises.

2.4.4 Competition in the host country or sector

Blomström, Globerman and Kokko (2001) argue that greater competition may induce multinational enterprises to transfer more (high-quality) technology to their subsidiaries, increasing the potential for knowledge spillover. Theoretical models by Glass and Saggi (1998), Wang and Blomström (1992), and others show that this may be the case. Empirical studies do not appear to have explicitly studied the mediating effect of host-sector competition on knowledge spillovers from FDI.[14]

2.4.5 Taking stock & discussion

Research on the knowledge spillover-mediating roles of absorptive capacity and technology gaps remains inconclusive. Comparing studies is difficult be-

[14] Kathuria (2002) examines the effect of liberalization of Indian industries between 1989 and 1997 on knowledge spillovers from FDI. Although liberalization increased competition in general, the reforms applied mainly to trade liberalization. The effect on knowledge spillovers occurred mainly through higher FDI.

cause of differences in methodologies and measurement. Future empirical research might benefit from convergence in definitions of absorptive capacity and backwardness. It may also be useful to start thinking about absorptive capacity as a relative concept (Girma 2005; Girma and Görg 2007). Investigating the nonlinear mediating effects of these factors also seems to be a promising direction for future research (Girma 2005; Girma and Görg 2007; Falvey et al., 2007).

Specific applications regarding the spatial dimension of knowledge spillovers from FDI remain limited; more theoretical work on this topic is needed. Are there reasons to believe that the spatial dimension of knowledge spillovers from FDI will differ from that of knowledge spillovers in general? The answer hinges on the specific spillover channel being considered. Knowledge spillovers transmitted through worker mobility are likely to be restricted geographically. The implications are less obvious for knowledge spillovers through vertical linkages and demonstration effects, because both supplier and customer relations and imitation and reverse engineering may easily cross national or regional borders. Studies investigating the spatial dimension of knowledge spillovers from FDI might benefit from clearly spelling out the spillover channels of interest and carefully considering their spatial dimension.

The influence of intellectual property rights regimes on FDI knowledge spillovers seems to be an important but neglected issue. More theoretical and empirical research is needed that analyzes the impact of intellectual property rights regimes directly on knowledge spillovers rather than indirectly through intrafirm technology transfer. Since the effect of intellectual property rights on knowledge spillovers is not clear *a priori* (because of offsetting mechanisms on spillover potential and appropriability), a great deal of insight can still be gained.

2.5 Multinational heterogeneity

> "To advance the literature on FDI spillovers, the questions "What kind of FDI?" and "What is the nature of MNC activity in the local market?" need to be addressed." (Feinberg and Keane, 2005: p. 269)

A third stream of research acknowledges the heterogeneity of multinational enterprises' foreign activities and the effect on FDI knowledge spillovers.

Some studies examine the relation between multinational enterprise ownership and knowledge spillovers. Others examine the relation between the nationality of the foreign investor or FDI motives and knowledge spillovers.

2.5.1 Ownership of the MNE

Müller and Schnitzer (2006) study the theoretical relation between knowledge spillovers and MNE ownership when the MNE engages in an international joint venture (IJV) with the host-country firm. They document a trade-off in which a larger ownership share induces the multinational enterprise to transfer more technology to its subsidiary, increasing spillover potential but reducing the extent to which the host-country firm is exposed to the technology. The actual relation between multinational enterprise ownership and knowledge spillovers may turn out to be an empirical matter

Empirical research usually distinguishes between minority FDI (the MNE holds a minority share in the foreign affiliate) and majority FDI (the MNE holds a majority share in the foreign affiliate):

$$y_{ijt} = \beta_0 + \beta_1 Min\_FDI_{jt} + \beta_2 Maj\_FDI_{jt} + \beta_3 \mathbf{X}_{it} + \beta_4 \mathbf{Z}_{jt} + \varepsilon_{ijt} \quad (2.8)$$

where Min_FDI and Maj_FDI measure the amount of minority and majority FDI in sector j. Some empirical studies (see below) use a distinction between Wholly Owned Subsidiaries (WOS) *versus* shared subsidiaries, and sometimes the intersectoral effects of different types of FDI are investigated as well.

Blomström and Sjöholm (1999) were among the first researchers to consider this relation empirically. Their study of 13,663 Indonesian manufacturing firms reveals that both minority and majority FDI lead to spillovers, with no statistical differences between the estimated effects.

Dimelis and Louri (2002) consider a sample of 4,056 Greek manufacturing firms. In separate regressions they analyze the relation between multinational enterprise ownership and knowledge transfer (to the local affiliate) and the relation between multinational enterprise ownership and knowledge spillovers (to other local firms). The results broadly confirm the theoretical predictions of Müller and Schnitzer (2006): only majority-owned foreign affiliates experience increases in productivity as a result of knowledge transfer, and minority FDI is more likely than majority FDI to produce knowledge spillovers.

Javorcik (2004b) analyzes a panel of about 4,000 firms in Lithuania, distinguishing between horizontal (intra-industry) and vertical (interindustry) spillovers. She finds that firms that are owned by both the foreign investor and a local firm create backward knowledge spillovers (to supplying industries), while wholly owned subsidiaries do not. She finds no evidence of horizontal or forward knowledge spillovers or statistical differences between the effects of minority and majority FDI.

Javorcik and Spatareanu (2008) analyze a panel of 13,129 Romanian firms. They find that shared foreign and domestic ownership induces positive vertical spillovers and negative horizontal spillovers. Wholly owned subsidiaries do not induce vertical spillovers and induce larger negative horizontal spillovers. These negative effects are explained by adverse competition effects.

Abraham, Konings, and Slootmaekers (2007) analyze the relation between minority- and majority-owned FDI and knowledge spillovers in an unbalanced panel of 17,645 plants in China. Their results show that minority FDI has a negative (competition) effect on locally owned enterprises' productivity and that majority FDI has no effect. The effect of minority FDI on foreign-owned enterprises is positive and larger than that of majority FDI.

2.5.2 Nationality of the parent company

Some recent studies argue that the nationality of the foreign investor affects the knowledge spillover effects of FDI. Most studies in this field consider FDI in China, comparing the effects of FDI from Hong Kong, China; Macau, China; and Taiwan, China, (HMT_FDI) on the one hand and from Western countries ($OTHER\_FDI$) on the other hand. The specification is similar to the one in model (2.8), with Min_FDI and Maj_FDI replaced by HMT_FDI and $Other\_FDI$.

Buckley, Clegg, and Wang (2007b) argue that HMT_FDI is less technologically advanced than FDI from outside China. As a result, although initial increases in such FDI may induce positive spillover effects, beyond some threshold level the negative competition effect starts to dominate. They therefore predict a nonlinear spillover effect of increased FDI from these sources. This contrasts with the positive linear effect of FDI from Western countries (the knowledge spillover effect is expected to dominate, because it carries more advanced technology). Their empirical analysis of 130 Chinese industries confirms their expectations: FDI from outside China has the expected (linear) positive effect (albeit only in high-technology sectors).

Buckley, Clegg, and Wang (2007a) investigate the relation between HMT_FDI and $OTHER\_FDI$ and productivity in a sample of 158 Chinese industries, taking into account receiving firms' and industries' characteristics. They find that such FDI generates more knowledge spillovers in labor-intensive industries and that FDI from outside China generates more knowledge spillovers in technology-intensive industries.

Abraham, Konings, and Slootmaekers (2007) show that the spillover effects of both minority and majority FDI from Hong Kong, Macau and Taiwan on locally owned enterprises are larger than those from FDI from other countries. The opposite holds for knowledge spillovers to foreign-owned enterprises.

Javorcik, Saggi, and Spatareanu (2004) compare the upstream knowledge spillover effects of FDI from Asian, European, and American (North and South) enterprises in a panel of 50,957 Romanian firms. They posit three reasons to expect weaker knowledge spillover effects from FDI from the European Union: the European Union is located closer to Romania, Romania was engaged in a preferential trade agreement with the European Union during the period of investigation, and inputs sourced from home-country suppliers by EU subsidiaries comply with Romania's rules of origin, which is not the case for Asian or American subsidiaries. All these mechanisms make knowledge spillovers through vertical linkages less likely for EU subsidiaries, because they stimulate imports of intermediate inputs from the European Union. The results confirm their expectations: FDI from Asia and America has positive vertical (upstream) knowledge spillover effects on Romanian firms. The effect is negative for FDI from the European Union, which the authors explain by pointing to increased competition in the downstream sector in which multinational enterprises are operating.

Girma and Wakelin (2007) distinguish between inward FDI into the United Kingdom from Japan, which accounts for the majority of R&D–intensive international companies in the electronics industry; from the United States, which has long invested in the British manufacturing industry; and from other countries. Their results indicate that Japanese and other international firms produce significant and positive knowledge spillover effects, whereas U.S. firms do not have a discernible spillover effect. The authors hint at the relatively high R&D-intensity of Japanese FDI as an explanation for this result.

In sum, many of the studies distinguishing between the nationality of subsidiaries' parent companies are in fact looking at relative home-host country or industry characteristics, such as R&D intensities, or labor and capital intensities of production. They then theorize about the expected effects of such differences on the existence and extent of knowledge spillovers from FDI, and investigate these expectations empirically. Consequently, the focus on the MNE's nationality is somewhat misleading, and potentially less informative than the characteristics that are actually investigated.

2.5.3 Motives for FDI

Most of the studies discussed above assume that FDI has knowledge spillover potential, i.e. that the firms engaging in FDI do so to exploit a technological or other ownership advantage abroad, part of which may spill over to the host country. This type of FDI is known as technology-exploiting FDI (Kuemmerle, 1999; Le Bas and Sierra, 2002). Most of the traditional literature on FDI refers to this type of investment (Hymer, 1960; Dunning, 1977; Markusen, 2002).

Scholars have recently pointed out a different type of FDI - technology-seeking FDI - which is motivated by a desire to source or seek external foreign knowledge (Dunning and Narula, 1995; Kuemmerle, 1999; Fosfuri and Motta, 1999; Siotis, 1999; Le Bas and Sierra, 2002). Firms engaging in technology-seeking FDI try to capture knowledge spillovers from firms in the host countries in which they invest. Knowledge spillovers are expected to flow from local firms to the multinational enterprise instead of the other way around.

A few studies investigate knowledge spillovers by distinguishing between these types of FDI. The empirical model is similar to that in model (2.8), with technology-exploiting and technology-seeking FDI substituted for Min_FDI and Maj_FDI. In a panel study of 11 manufacturing sectors in the United Kingdom, Driffield and Love (2007) find that technology-sourcing FDI did not generate knowledge spillovers, whereas technology-exploiting FDI did. Girma (2005) obtains similar results.

FDI can also be classified as horizontal (Markusen, 1984), vertical (Helpman, 1985), or export platform (Ekholm, Forslid, and Markusen, 2007). Horizontal FDI is usually motivated by market-seeking incentives, vertical FDI by efficiency- or resource- seeking incentives, and export-platform FDI by the desire to find an efficient location from which to export more profitably to third countries. The extent of knowledge spillovers from these types of FDI may differ (Javorcik and Spatareanu, 2005; Driffield and Love, 2007).

Protsenko (2003) examines the spillover effects of horizontal and vertical German FDI in the Czech Republic. He finds that vertical FDI generates positive knowledge spillovers, whereas horizontal FDI has effects largely through increased competition. These results suggest that the distinction between horizontal, vertical, and export-platform FDI is potentially important in determining the extent of knowledge spillovers.

2.5.4 Taking stock & discussion

The work on the relation between multinational enterprise ownership and knowledge spillovers has strong intuitive appeal, because it seems likely that not all types of subsidiaries (minority, majority) generate the same knowledge spillovers. Theoretical work in this area is scant, however; more insights are needed to guide empirical work.

The empirical results obtained so far are difficult to compare, because they take slightly different approaches. A fruitful extension in this area, particularly in theoretical work, would be to consider the influence of multinational enterprise ownership along a continuum. Instead of analyzing the spillover effect of different categories of subsidiaries (minority, majority), researchers might analyze the influence of actual ownership shares (0–100 percent) on local firms' productivity. Such an approach would allow researchers to analyze nonlinear effects.

Studies distinguishing between the country-origin of FDI often do so based on a variety of economic rationales (such as differences in expected R&D intensities, or differences in local input sourcing). Future research should investigate whether these more general underlying economic rationales can be used to distinguish different types of FDI, instead of the more specific country of origin. Such an approach may both stimulate the development of more theoretical research in this area, as well as a more general empirical application.

Distinguishing FDI motives may contribute to a better understanding of the likelihood of knowledge spillovers from FDI. Theoretical models in this field have looked only at the relation between FDI motives and firm heterogeneity. A useful extension would be a model in which the extent of knowledge spillovers is endogenously determined by firms' motives in pursuing FDI. Also more empirical research is needed that directly investigates this relation: Although the few studies reviewed above indicate that technology-

Table 2.3: FDI heterogeneity and knowledge spillovers - Empirical studies

Factor	Study	Sample	Results
MNE ownership	Blomström and Sjöholm (1999)	13,663 manufacturing firms in Indonesia: 1991	Minority and majority FDI shares have equal spillover effects
	Dimelis and Louri (2002)	4,056 manufacturing firms in Greece: 1997	Minority FDI shares have greater spillover effect than majority FDI shares
	Javorcik (2004b)	4000 firms in Lithuania: 1996-2000	Shared foreign and domestic ownership has positive spillover effect
	Javorcik and Spatareanu (2008)	All firms in Romania: 1998-2003	Share foreign and domestic ownership has positive vertical spillover effect and negative horizontal spillover effect
	Abraham, Konings and Slootmaekers (2006)	17,645 plants in China: 2000-2004	Minority FDI shares have greater spillover effect than majority FDI shares
Nationality of parent company	Buckley, Clegg and Wang (2007b)	130 industries in China: 1995	No effect for FDI from Hong Kong, Macau and Taiwan, Positive effect for FDI from other countries inhigh-technology sectors
	Buckley, Clegg and Wang (2007a)	158 industries in China: 2001	Positive effect for FDI from Hong Kong, Macay and Taiwan in labor intensive industries Positive effect from FDI from other countries in tech. intensive industries
	Abraham, Konings and Slootmaekers (2006)	17,645 plants in China: 2000-2004	Larger effect for FDI from Hong Kong, Macau and Taiwan on locally owned enterprises The opposite for foreign-owned enterprises
	Javorcik, Saggi and Spatareanu (2004)	50,957 firms in Romania: 1998–2000	FDI from Asia and America has positive upstream spillover effects FDI from the EUhas negative spillover effects
	Girma and Wakelin (2007)	11,000 plants and 10 NUTS UK: 1980-1992	FDI from Japan and other countries has positive spillover effects FDI from the US has no spillover effects
Motive for FDI	Girma (2005)	7,516 firms in UK: 1989-1999	Exploiting FDI has positive spillover effects Sourcing FDI has no spillover effects
	Driffield and Love (2007)	11 manufacturing sectors in UK: 1987–97	Exploiting FDI has positive spillover effects Sourcing FDI has no spillover effects
	Protsenko (2003)	256 German FDI projects Czech Republic: 1993-1999	Vertical FDI has positive spillover effects Horizontal FDI has no spillover effects

seeking FDI does not generate knowledge spillovers, more recent empirical research indicates that this type of FDI may at least have a large potential of doing so (Feinberg and Gupta 2004; Cantwell and Mudambi 2005).

Finally, more research investigating the differential knowledge spillover effects of horizontal, vertical, and export-platform FDI, or more generally, the differences in market orientation of FDI, is also warranted. Not only do differences in market orientation have different implications for potentially adverse competition effects, they may also affect the input sourcing decisions, thereby affecting the extent of knowledge diffusion through backward linkages. Furthermore, given that export-market oriented FDI is by definition aimed at producing for foreign markets, its subsequent knowledge diffusion effects through forward linkages are by definition largely absent.

2.6 Conclusion

> "If country and industry differences are important to the impact of inward FDI on host countries, the main lesson might be that the search for universal relationships is futile." (Lipsey and Sjöholm, 2005: p. 40)

With so many dimensions and so many factors at the country, sector, regional, and firm level influencing the relation between FDI and knowledge spillovers, the search for universal relations may well be futile. This does not imply that the search for knowledge spillovers from FDI is futile, however.

The studies surveyed in this chapter that explicitly investigate the individual knowledge spillover channels identified in Figure 2.1 (and summarized in Table 2.1) all seem to conclude that knowledge spillovers from FDI do occur through these channels (except through forward linkages). Explicitly taking into account these knowledge spillover channels seems to be an important step forward in this literature.

The literature on mediating factors and FDI heterogeneity is inconclusive, at least partly because of the lack of comparability across studies caused by differences in methodologies and measurement. Several changes could improve results. First, researchers could move toward convergence, for example, by uniformly measuring absorptive capacity as a relative concept or measuring multinational enterprise ownership along a continuum rather than as a categorical variable.

Second, any study of knowledge spillovers should specify the channels analyzed. Such an approach would clearly delineate the possible role of mediating factors or FDI heterogeneity. For example, the relevance of the spatial dimension as a mediating factor for knowledge spillovers strongly depends on the spillover channels considered; different types of FDI may work through different channels to different extents.

Third, deeper insight into the (conditional) existence of knowledge spillovers from FDI is not likely to come from any of the outlined approaches individually. Spillover channels, mediating factors, and FDI heterogeneity coexist and interact in determining the extent of knowledge spillovers. Theoretical and empirical research should therefore try to address them simultaneously (Wei and Lui, 2006; Liang, 2008). Does the importance of absorptive capacity for capturing knowledge spillovers through demonstration effects vary with the degree of multinational enterprise ownership? Is the spatial dissipation of knowledge spillovers through backward linkages different for horizontal and vertical FDI? These kinds of interrelated questions should guide future work on this topic, and they will also underly the next chapters of this thesis as far as the data allow.

Specifically, this chapter has demonstrated that the interest for the heterogeneity of MNEs and its implications for knowledge spillover effects is a timely and promising strand of research. In Section 2.5 we have identified a number of questions and issues that so far have remained unaddressed in the literature, and that we will pick up in the remainder of this thesis. Chapter 3 considers the relationship between MNE ownership over its foreign subsidiaries and the productivity effects it generates, with MNE ownership measured on a continuum. Here, we will also investigate whether differences in MNE ownership affect the extent of horizontal and vertical productivity effects differently, and in which way the strength of Intellectual Property Rights protection impacts on these relationships. Given the limited work on the market-orientation of MNEs and the associated productivity effects as identified in Section 2.5.3 (horizontal, vertical and export platform FDI), Chapter 4 investigates this dimension of MNE heterogeneity. Again, we will consider both the horizontal and the vertical productivity effects of FDI, and additionally, we will also investigate the mediating impact of geography through Regional Integration Agreements (RIAs) on these effects. Finally, in Chapter 5 we contribute to the literature linking FDI motives for technology exploitation and sourcing to the productivity effects it generates. We make both a theoretical contribution by allowing for alternative technology exploiting and seeking strategies, as well as an empirical contribution by introducing alternative ways of distinguishing between the FDI types.

Two important overarching issues need to be noted. First, empirical work too often ignores the conceptually important distinction between intentional knowledge transfers and unintentional knowledge spillovers. As Blalock and Gertler (2005, 2007) and Javorcik and Spatareanu (2005) clearly show, many of the estimated effects are more likely related to knowledge transfer than knowledge spillover. From a policy perspective this distinction is very important: whereas the existence of knowledge spillovers (which are externalities) clearly warrants interventionist government policy, the existence of knowledge transfer (which takes place through market mechanisms) clearly does not.[15] Mistakenly assigning the beneficial productivity effects of FDI to knowledge spillovers may convince governments of many developing countries to undertake costly and wasteful FDI policies. Future empirical work on this topic should be very careful in labeling estimated positive effects of FDI as spillovers and even more careful in deriving far-reaching (costly) policy implications from them. In the remainder of this thesis, we will always be explicit about the distinction between the pure knowledge spillover and the other effects generated by FDI that together make up the productivity effect.

Second, a wide gap remains between theoretical and empirical research (one exception is Alfaro and Rodríguez-Clare, 2004). Theory and empirics have developed more or less independently. In many of the areas reviewed above, more theoretical work is needed. The definition and functioning of demonstration effects, the spatial dimension of knowledge spillovers from FDI in interaction with different spillover channels, and the relation between various motives for FDI and knowledge spillovers are just a few of the areas in which theory to guide future empirical work has been lacking. Chapters 3 and 5 will try to fill this gap by developing explicit formal theoretical frameworks.

[15] If backward knowledge transfers increase competition in supplying industries, reducing prices on intermediate goods and end products, the wealth of consumers in the host country rises, so that the social returns of knowledge transfer exceed the private returns. In this case interventionist government policy could be warranted, as Blalock and Gertler (2007) note.

Chapter 3

Multinational Ownership, Intellectual Property Rights and Knowledge Diffusion from Foreign Direct Investment

3.1 Introduction

As noted in the previous chapter, academic research has increasingly taken into account the heterogeneity of multinationals (MNEs) and their foreign subsidiaries, attempting to better disentangle the conditions under which Foreign Direct Investment (FDI) induces knowledge spillovers. Whereas FDI used to be treated as a rather bulky and homogeneous concept, scholars have started to acknowledge the heterogeneity of MNEs in *inter alia* investment motives, market orientation and country of origin, and the subsequent consequences for host-country knowledge spillovers.

As discussed in Section 2.5.1, a particularly promising strand of research has considered differences in MNE ownership over foreign affiliates as a determining factor of knowledge spillovers. There are several theoretical and empirical grounds on which the extent of MNE ownership in its subsidiaries might influence the host-country productivity effects in generates. For instance, internalization theory suggests that increased MNE ownership over a foreign affiliate induces the parent to transfer more proprietary knowledge

[15] This chapter is based on Smeets and De Vaal (2008).

or technology abroad, thus increasing the potential for knowledge diffusion (Rugman, 1981; Hennart, 1982; Davies, 1992). Moreover, studies on MNE input sourcing suggest that increased MNE ownership has consequences for the extent of local input sourcing, thus affecting the extent of backward linkages (Tavares and Young, 2006; Javorcik, 2008).

The empirical studies discussed in Section 2.5.1 usually distinguish minority from majority ownership (Blomström and Sjöholm, 1999; Dimelis and Louri, 2004), or shared ownership from fully owned subsidiaries (Javorcik, 2004a; Javorcik and Spatareanu, 2008) and indeed find that the distinction matters. However, as mentioned in Section 2.5.4, none of these studies considers the effect of MNE ownership as a continuous parameter, which veils a lot of the potential variation. Moreover, we also found that although some theoretical studies investigate the relationship between intra-firm knowledge transfer and MNE ownership (Müller and Schnitzer, 2006), theoretical contributions on the relationship between MNE ownership and intra and inter-industry knowledge diffusion are largely absent.

This chapter first deals with the latter shortcoming in the literature: We introduce shared ownership between a MNE and a local (host-country) partner in the foreign subsidiary as a variable of interest in a theoretical model by Markusen and Venables (1999), and then consider its host-country intra and inter-industry effects. Specifically, in addition to considering only pecuniary externalities, as is common in most theoretical models, we also consider actual knowledge diffusion. In doing so, the analysis explicitly considers two forms of knowledge diffusion: First, knowledge spillovers, which are unintended knowledge flows (i.e. externalities) from the MNE to its host-country environment. Second, knowledge transfers, which are intended (and internalized) flows of knowledge from the MNE to its host-country environment. A final contribution of this chapter is that it also considers institutional heterogeneity - notably intellectual property rights protection (IPP) - and how this interacts with the two types of knowledge diffusion just mentioned. As such, it deals with yet another caveat in the literature, as mentioned in Section 2.4.3.

Our theoretical results demonstrate the opposing influences of pecuniary effects, direct and indirect demand effects, and knowledge diffusion on domestic firms, following from an increase in MNE ownership in foreign affiliates. Nonetheless, we are able to derive some (conditional) unambiguous predictions: We find that forward or downstream host-country effects following an increase in MNE ownership are generally positive, provided that there is sufficient downstream competition. In this way, our findings also add to the relatively limited literature on the mediating effects of host-country competition (*cf.* Section 2.4.4). Backward or upstream effects are also positive in countries with high IPP, provided that *inter alia* downstream demand elasticities and local input shares are sufficiently high. The intra-industry effects are generally positive in low-IPP countries, provided that the share of fixed costs in total costs of domestic firms is sufficiently high.

This chapter also takes these theoretical predictions to the data. It employs a firm-level panel dataset, containing 1,222 large domestic firms and 327 foreign subsidiaries with varying degrees of MNE ownership, active in 20 countries and 18 industries during the period 2000-2005. Unlike earlier empirical studies, we treat MNE ownership as a continuous parameter instead of as a dichotomous concept. Our theoretical findings on the inter-industry effects are largely confirmed by the data. The empirical results on the intra-industry effects are not entirely in line with the theoretical expectations, which we argue might be due to specific assumptions in the model. Generally speaking, the empirical results suggest that high-IPP countries are better able to reap the benefits of MNE investment than low-IPP countries.

The empirical part of the chapter also provides two methodological advantages over some of the earlier studies already undertaken in this area (*cf.* Blomström and Sjöholm, 1999; Dimelis and Louri, 2002; Javorcik, 2004a; Javorcik and Spatareanu, 2008). First, unlike earlier studies, we utilize a cross-country sample which allows us to investigate how institutional heterogeneity (such as differences in IPP regimes) interacts with the relationship between MNE ownership and host-country productivity effects. Second, in stead of considering dichotomous or discrete differences in MNE ownership (e.g. minority *versus* majority, or shared ownership *versus* full ownership), we treat MNE ownership as a continuous variable in the empirical part as well. Given the *ex ante* theoretical ambiguity of the relationship between MNE ownership and knowledge diffusion, next to the usual parametric regression techniques we also employ semi-parametric regression techniques which allows us to refrain from specifying a specific functional form regarding the relationships of interest.

The rest of this chapter is structured as follows: section 3.2 develops the theoretical model, based on Markusen and Venables (1999) and extends it with the theoretical elements mentioned above. Section 3.3 analyzes the within and between industry-effects of changes in MNE ownership on local firms, and how these effects depend on the extent of IPP. Section 3.4 outlines the empirical method and gives an overview of the data used in this chapter. Section 3.5 presents the estimation results of the empirical model. Finally, Section 3.6 concludes.

3.2 The model

Before discussing the setup of the model, it is instructive to consider Figure 3.1 below, which presents a schematic representation of the theoretical model. A MNE sets up a shared foreign subsidiary in sector k in the host economy to produce for and sell to the local market. As such, it competes with local firms that are also active in sector k, but at the same time it also spills over knowledge to these firms. These are *intra-industry* or *horizontal* knowledge spillovers. The industry the MNE invests in may be a downstream industry – receiving inputs from local firms in j as indicated by situation A – or an upstream industry – delivering inputs to firms in industry l as indicated by situation B. If situation A is at hand, local firms active in sector j supply the foreign subsidiary and local firms in sector k with intermediates, but at the same time also receive knowledge transfer from the foreign subsidiary, e.g. through supplier assistance (Javorcik, 2008). This type of knowledge transfer is called backward or upstream knowledge transfer. If situation B is relevant, the foreign subsidiary and local firms in sector k function as input suppliers themselves, selling intermediates to local firms in sector l. Simultaneously, these local sector l firms may receive knowledge transfer from the foreign subsidiary, e.g. in the form of increased input quality (Javorcik, 2008). Whichever situation occurs, these types of knowledge transfer are *inter-industry* or *vertical* in nature. In addition to vertical knowledge transfer, changes in the demand and supply of goods along the input and output linkages will cause backward and forward demand effects, leading to pecuniary spillovers.

In what follows we will first focus on part A of Figure 3.1. That is, we will first consider the situation in which the MNE has a shared subsidiary in the downstream sector (k) of the host economy and receives supplies from the upstream sector (j). After having derived the model for this setup, we will also indicate how the model changes when considering part B, where the foreign subsidiary is active in the upstream sector (k), supplying local firms in the downstream sector (l).

In our model there are two types of firms: Multinationals (m) and na-

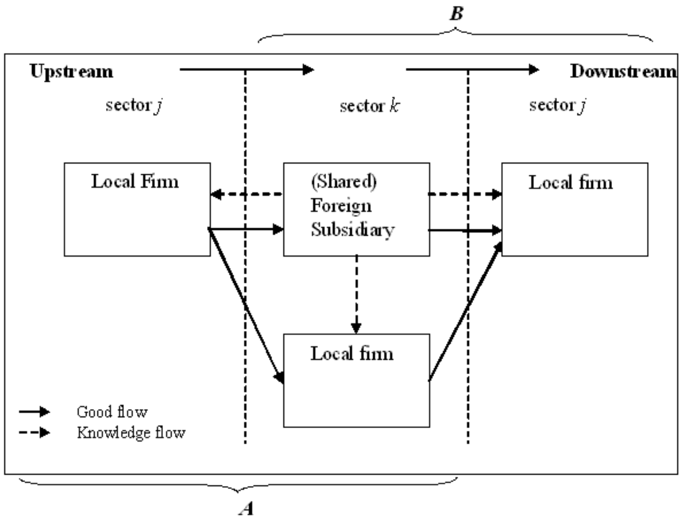


Figure 3.1: Schematic representation of horizontal and vertical linkages

tional firms (n), where the latter can be further classified as local partners (lp), downstream firms (d) and upstream firms (u). We assume that MNEs require a local partner to set up a foreign subsidiary in the host country: The resulting shared subsidiary can be thought of as an International Joint Venture (IJV).[16] This IJV competes with the downstream firm d, and both of them are supplied by the upstream firm u.

The theoretical model below builds on and extends Markusen and Venables (1999). These authors develop a multi-sector partial equilibrium model, where they analyze the effect of MNE entry in a downstream industry on the number of local firms active in upstream and downstream industries. The effects of MNE entry work via competition effects and demand linkages (leading to pecuniary externalities). Our setup resembles theirs in a number of

[16] A couple of remarks apply here: First, note that we assume that the MNE needs a local partner, i.e. we do not model the decision between a greenfield versus a shared subsidiary nor the search process for a suitable partner. Second, even though the shared subsidiary may be thought of as an IJV, we assume that the national firm is completely absorbed in the partnership and does not have any remaining operations of its own. From that perspective, the partnership may have more resemblance to a partial acquisition. Third, we assume that there is always a sufficient supply of local partners.

ways: We also utilize a two industry setup, in which each industry is characterized by Dixit-Stiglitz monopolistic competition. Further, we also look at pecuniary externalities via demand linkages between the upstream and downstream industries. Yet our model also differs from theirs on several important aspects: First, we introduce shared ownership between the MNE and a local partner in the foreign subsidiary, as investigating the effect of a change in MNE ownership on the productivity of local firms is the primary focus of this paper. Second, next to pecuniary spillovers, we also introduce direct and explicit knowledge diffusion. Moreover, we disentangle these knowledge diffusion effects into knowledge spillovers (horizontal) and knowledge transfers (vertical), and consider their contingency on IPP protection. Finally, we do not consider the effect of MNE entrance or ownership on the entry or exit of local firms, by keeping the number of firms constant when taking total derivatives (*cf.* Section 3.3).

Recall that we first consider part A of Figure 3.1, where $IJVs$ are active in the downstream industry (together with local downstream firms d) and are supplied by local upstream firms u. We model the price index of the inputs produced by local upstream firms in CES fashion and denote it by:

$$P_U = \left(n_u p_u^{1-\sigma}\right)^{1/(1-\sigma)} \tag{3.1}$$

where n_u are the number of local upstream firms, p_u are individual prices of upstream inputs and $\sigma > 1$ is the elasticity of substitution between any two input varieties. Suppose for the moment that total demand for inputs from the downstream sector is given by I. Then, multiplying P_U by I gives total costs of input supply, or equivalently, total expenditures on inputs. Hence, we can apply Shephard's lemma to derive demand for individual inputs x_u:

$$x_u = p_u^{-\sigma} I P_U^{\sigma} \tag{3.2}$$

In the downstream sector we have a similar industry structure, but here both national firms and IJVs are active. Hence, the price index in the downstream sector is given by:

$$P_D = (n_d p_d^{1-\varepsilon} + n_{IJV} p_{IJV}^{1-\varepsilon})^{1/(1-\varepsilon)} \tag{3.3}$$

where n_d (n_{IJV}) is the number of local firms (IJVs) active in the downstream sector, p_d (p_{IJV}) are the prices these firms charge, and $\varepsilon > 1$ is the elasticity of substitution between any two varieties. The volume of total consumer demand for these downstream products is given by Y and total expenditure on downstream goods is given by $YP_D^{-\eta}$ where η is the elasticity of demand with respect to the price index P_D. Similar to Markusen and Venables (1999), we assume that $\varepsilon > \eta > 1$. Again applying Shephard's lemma we obtain individual demands:

$$\begin{aligned} x_d &= p_d^{-\varepsilon} Y P_D^{\varepsilon-\eta} \\ x_{IJV} &= p_{IJV}^{-\varepsilon} Y P_D^{\varepsilon-\eta} \end{aligned} \tag{3.4}$$

On the production side of the economy we have IJVs and national firms, of which the latter are active both in the same sector as the IJV, as well as in upstream and downstream sectors (Figure 3.1 - part A). First consider the profit function of the IJV which is given by:

$$\Pi_{IJV} = p_{IJV} x_{IJV} - (F_{IJV} + \beta_{IJV} x_{IJV}) \left[\alpha P_U + (1-\alpha) w\right] \tag{3.5}$$

where p denotes price, x denotes output, F are fixed costs, β are marginal production costs, w is the wage rate of labor, and α is the share of inputs sourced from the upstream sector $(0 \leq \alpha \leq 1)$. Note that the amount of inputs sourced from the upstream sector depends on the amount of fixed costs and variable costs. The remaining share $(1-\alpha)$ is spent on labor as an additional production factor.

As mentioned, the IJV is a partnership between a MNE (m) and a local partner (lp). We assume that the contribution of both firms in terms of technology and knowledge to the IJV is proportional to their ownership shares in the IJV, which is given by ρ for the MNE and $(1-\rho)$ for the local partner. These contributions translate into the fixed and marginal production costs of the IJV and are modelled as follows:

$$\begin{aligned} F_{IJV} &= \rho F_m + (1-\rho) F_n \\ \beta_{IJV} &= \rho \beta_m + (1-\rho) \beta_n \end{aligned} \tag{3.6}$$

where we assume $F_{lp} = F_d = F_u \equiv F_n$, i.e. fixed costs of all national firms are equal, regardless of their type, and similarly for β. In line with earlier literature (Blomström and Sjöholm, 1999; Helpman, Melitz and Yeaple, 2004), as well as with the firm characteristics in our own sample (see Section 3.5.1), we assume that $F_m < F_n$ and $\beta_m < \beta_n$ i.e. the MNE is more productive than a national firm, both in terms of fixed costs as well as marginal costs. Hence, the larger the ownership share of the MNE in the IJV, the lower

IJV fixed and marginal costs will be, which is in line with the literature on internalization or transaction costs and technology transfer (Davies, 1992).

A key issue of this chapter is the nature and extent of knowledge diffusion from the IJV to the national firms. As explained at length in Chapters 1 and 2, we make an explicit distinction between unintended knowledge spillovers on the one hand, and intended knowledge transfer on the other. This distinction is especially important in the present context, since we conjecture that the type of knowledge diffusion is contingent on the direction of diffusion, i.e. horizontal or vertical.

Specifically, we argue that knowledge spillovers from the IJV are most likely to flow horizontally, i.e. to downstream firms d active in the same sector, for the IJV has nothing to gain from intentionally transferring knowledge or technology to its competitors. Moreover, since these firms are active in the same sector, their absorptive capacity can be expected to be relatively high. Intentional knowledge transfers on the other hand, are more likely to flow vertically, i.e. from the IJV to local upstream firms u (in situation A of Figure 3.1), since the IJV will benefit from this by increased quality or decreased prices of inputs. Indeed, there exists ample evidence of MNEs that assist their suppliers in terms of technology transfer, or transfer of best practices or quality standards (Javorcik and Spatareanu, 2005; Javorcik, 2008).[17]

In the context of knowledge diffusion, the extent of IPP also becomes relevant (Branstetter, Fisman and Foley, 2006) since the purpose of IPP is to reduce knowledge spillovers. As a consequence we may expect opposite effects of IPP on (horizontal) knowledge spillovers on the one hand, and (vertical) knowledge transfer on the other hand: if IPP functions properly, horizontal knowledge spillovers should be reduced. At the same time however, due to the decreased risk of expropriation of knowledge, this increases the incentives for the IJV to (vertically) transfer knowledge. Hence, upstream knowledge transfer should increase with IPP.[18]

As we have assumed that MNE knowledge transfer to the IJV takes effect through fixed and marginal costs, it is only natural to assume that knowledge diffusion from the IJV to downstream and upstream firms will also affect their fixed and marginal cost structures. Hence, for local downstream firms,

[17] We do not consider explicit learning within the IJV by any of the two parties involved (for an analysis of this type, see Müller and Schnitzer, 2006).

[18] Apart from the theoretical relevance of introducing IPP in this manner, its opposite effects on knowledge spillovers and transfers also help us to interpret our hypothesized difference between horizontal and vertical knowledge diffusion empirically.

we model fixed and marginal costs after spillovers as:

$$\begin{aligned} F_d^S &= \theta F_d + (1-\theta) F_{IJV} \\ \beta_d^S &= \theta \beta_d + (1-\theta) \beta_{IJV} \end{aligned} \tag{3.7}$$

where θ is a parameter capturing the strength of Intellectual Property Rights protection (IPP), with $\theta = 1$ denoting perfect protection and $\theta = 0$ no protection whatsoever. Hence, spillovers are maximized when $\theta = 0$, implying that the fixed and marginal cost structures of IJVs can be copied perfectly.

For intentional knowledge transfers from the IJV to upstream local firms we then have:

$$\begin{aligned} F_u^T &= (1-\theta) F_u + \theta F_{IJV} \\ \beta_u^T &= (1-\theta) \beta_u + \theta \beta_{IJV} \end{aligned} \tag{3.8}$$

Note that because knowledge transfer is intentional (as opposed to spillovers) the IJV is more willing to transfer its technology as the extent of IPP increases (θ increases), since the risk of expropriation is very small in that case (Branstetter et al., 2006).

The local upstream firm has the following formulation for profits:

$$\Pi_u = p_u x_u - (F_u^T + \beta_u^T x_u) w \tag{3.9}$$

We can derive the equilibrium price for the upstream firm by substituting equilibrium demand (3.2) into (3.9) and maximize profits, which yields:

$$p_u = \frac{\sigma \beta_u^T w}{(\sigma - 1)}$$

It directly follows from this expression that MNEs benefit from technology transfer to upstream firms, since this decreases β_u^T and hence decreases input prices p_u.

Local downstream firms have the following profit function:

$$\Pi_d = p_d x_d - (F_d^S + \beta_d^S x_d)(\alpha P_U + (1-\alpha) w) \tag{3.10}$$

the interpretation of which is similar to that of the IJV.[19] The equilibrium

[19] Note that we assume (unlike Markusen and Venables, 1999) that $\alpha_{IJV} = \alpha_d = \alpha$. Although it has been argued that MNEs (or IJVs) will potentially source less of their inputs in the host-country, we have no way of distinguishing between α_{IJV} and α_d in the empirical part of the paper, so that we prefer the current specification. However, we will come back to the implied relationship between α and ρ when discussing the empirical results in Section 3.5.

pricing condition is found by substituting x_d from (3.4) into (3.10) and maximizing profits:

$$p_d = \frac{\varepsilon\beta_d^S(\alpha P_U + (1-\alpha)w)}{(\varepsilon - 1)}$$

Note that on top of the knowledge spillovers through β_d^S, the backward demand linkage from MNEs to upstream firms poses an additional benefit to the local downstream firm as it serves to decrease P_U as well, which constitutes an (indirect) forward linkage.

Finally, for the IJV we obtain a similar pricing condition:

$$p_{IJV} = \frac{\varepsilon\beta_{IJV}(\alpha P_U + (1-\alpha)w)}{(\varepsilon - 1)}$$

We can now close the model by also writing down derived demand for the upstream firm's products, which is generated by the input demand from the IJV and the domestic firm in the downstream sector:[20]

$$I = \alpha n_{IJV}(F_{IJV} + \beta_{IJV}x_{IJV}) + \alpha n_d(F_d^S + \beta_d^S x_d) \tag{3.11}$$

So far, we have only considered part A of Figure 3.1, i.e. the situation in which the IJV is active in the downstream sector generating horizontal intra-industry effects as well as upstream or backward effects through inter-industry linkages. In order to analyze downstream or forward linkages, we also consider the situation in which the IJV is active in the upstream industry (together with local firms) and supplying local firms in the downstream industry. That is, part B of Figure 3.1.[21] Because the model remains largely

[20] Coming back to our earlier remark, we again note that we refrain from deriving free entry (i.e. zero profit) conditions, but instead assume that these are fulfilled in both sectors. A potential problem in this case is that the cost structure of the two firm types in the downstream sector (IJVs and ds) differ. Specifically, given that IJVs are more efficient than ds, imposing a zero-profit condition for ds would imply positive profits for IJVs. In order to prevent this situation from ocurring, we assume that any resulting positive profits from IJVs are absorbed by added coordination costs between the MNE and its local partner.

[21] We already noted above that in the model setup discussed so far, we do have *indirect* forward linkages to the downstream local firms which are contingent on the upstream linkage, since they will be affected by changes in P_U induced by changes in MNE ownership in the IJV (ρ). However, in the empirical section, we will also investigate the *direct* forward linkages, i.e. the linkage effects of an IJV directly supplying local firms, so that we also have to consider this case theoretically.

the same, except for the fact that the IJV switches industries, we will not fully write it down here (see Appendix A to this chapter). However, note that in this case it is the upstream firm that benefits from knowledge spillovers, whereas the downstream firm benefits from knowledge transfer. This also implies that the moderating effects of IPP change accordingly. In the next section we will analyze the comparative static effects of a change in MNE ownership in the IJV (ρ) on the profits of local firms for both situations A and B.

3.3 Intra and inter-industry effects of MNE ownership

3.3.1 IJVs in the downstream sector

Since our main interest in this chapter concerns the effects of MNE ownership in the IJV (ρ) on local firms through demand linkages, price effects and knowledge diffusion, we investigate the effect of ρ on local firms' profits. In order to do this, we compute total derivatives with respect to ρ while assuming that all other variables remain unchanged. First consider the effect of MNE ownership in the downstream industry on upstream firms' profits:

$$\frac{d\Pi_u}{d\rho} = \frac{p_u^{1-\sigma} P_U^{\sigma}}{\sigma} \underbrace{BL_1}_{\gtreqless 0} + \frac{p_u}{\sigma} \underbrace{PE_1}_{<0} + \underbrace{KT_1}_{>0} \tag{3.12}$$

where BL_1, PE_1 and KT_1 are a backward linkage effect, a price effect and a knowledge transfer effect respectively, the full expressions of which are given in Appendix B1.

The knowledge transfer effect KT_1 is straightforward: An increase in MNE ownership in the IJV increases explicit knowledge transfer to the upstream firm by decreasing fixed and variable costs, increasing upstream firms' profits. Moreover, the larger the IPP (i.e. the larger θ), the larger is this positive effect.

The negative upstream price effect PE_1 is due to our assumption of homogeneity of upstream firms and their interrelationships, so that all upstream firms are affected by an increase in ρ in the same way. Specifically, the decrease in β_u^T following an increase in ρ decreases upstream prices p_u. Although that would *ceteris paribus* increase demand for upstream products, this positive effect is offset by the reduction in the price index of the upstream industry P_U following a decrease in p_u. The only effect that remains are lower operating profits per firm, since marginal costs and hence prices have decreased. This effect is stronger the larger is θ due to increased knowledge transfer.

The effect of ρ through the backward demand linkage (BL_1) has three components in $d\Pi_u/d\rho$ (see Appendix B1). First, there is a negative indirect knowledge spillover effect, which occurs because of the increase in knowledge spillovers to the local downstream firm as a result of an increase in ρ, making downstream firms more efficient. This implies less demand for x_u since less inputs are needed to produce the same output. Also note that the negative effect of knowledge spillovers is moderated by the extent of IPP: The larger θ, the smaller knowledge spillovers to the local downstream firm and hence, the smaller its negative influence on demand for intermediate inputs. This adds to the positive *direct* effect of θ through KT_1.

Second, there are positive downstream demand effects, induced by the change in demand for downstream firm products after an increase in ρ. Since fixed and marginal costs of downstream firms are reduced, as well as the fact that input prices P_U go down, prices for downstream products fall, inducing an increase in demand for downstream products and accordingly also for upstream inputs. The impact of θ on this effect is twofold: On the one hand, an increase in θ decreases knowledge spillovers to local downstream firms, thus limiting the price decrease of these firms and limiting the increase in derived input demand. On the other hand, an increase in θ raises knowledge transfer to the upstream firm, lowering input prices and hence downstream prices, thus increasing derived demand for inputs again. However, this latter effect is a second order effect (i.e. it only takes place after the knowledge transfers to upstream firms have found their way into higher demand for downstream products) so that in this case, IPP will most likely exert a negative effect on Π_u.

The third effect which takes place through the backward demand linkage (BL_1) is a downstream price effect. As we will see below as well (when analyzing $d\Pi_d/d\rho$) an increase in ρ decreases individual prices of all downstream firms, and thereby also the price index P_D. That is to say, an increase in ρ eventually decreases per firm revenue in the downstream sector. This in turn has a negative impact on derived demand for upstream inputs and accordingly on upstream profits.

We now turn to the national firm in the downstream industry (i.e. the competitor of the IJV). Recall that two clear differences with the upstream firm are that (i) the downstream firm is not vertically linked with the IJV and (ii) knowledge diffusion occurs through knowledge spillovers rather than knowledge transfer. Computing the total derivative of Π_d with respect to ρ yields:

$$\frac{d\Pi_d}{d\rho} = (\varepsilon - \eta)\frac{p_d}{\varepsilon}\frac{x_d}{P_D}\underbrace{PE_2}_{<0} + \underbrace{KS_1}_{>0} + \underbrace{IDL_1}_{>0} \tag{3.13}$$

where PE_2, KS_1 and IDL_1 are a price effect, a knowledge spillover effect, and an indirect demand linkage effect respectively (the explicit expressions are relegated to Appendix B2).

First, the price effect (PE_2) works through the price index P_D. Due to the increase in ρ, IJV cost structures improve because of increased intra-firm knowledge transfer, making IJVs more competitive. Moreover, since the increase in ρ also increases horizontal knowledge spillovers, contingent on the lack of IPP $(1 - \theta)$, each individual national firm in the downstream industry is confronted with a decrease in P_D, a decrease in per firm revenue, and hence a decrease in profits.

Second, there is the direct knowledge spillover effect (KS_1), occurring through the fixed and marginal cost structure and again contingent on the absence of IPP protection $(1 - \theta)$. This effect is obviously positive.

Finally, the downstream national firm also profits from the vertical linkage between the IJVs and the upstream firms, albeit in an indirect way via P_U (IDL_1). Indeed, since backward knowledge transfer from the IJV to the upstream firm increases with ρ (see above), national downstream firms are confronted with lower input prices P_U. The extent of this positive indirect linkage is contingent on the input share α as well as on the extent of IPP θ. Regarding the latter, this poses a counteracting force to the direct knowledge spillovers from the IJV to the downstream firm: To benefit more from these spillovers, the downstream firm requires a lower θ (first-order), but to benefit from lower input prices, it requires a higher θ (second-order).

3.3.2 IJVs in the upstream sector

Now we will consider the situation in which the IJVs (and local firms) are active in the upstream sector, hence supplying local firms in the downstream sector (situation B in Figure 3.1). The analysis is similar to the one before, but recall that in this situation the local upstream firms benefit from knowledge diffusion through knowledge spillovers, whereas the downstream firms receive MNE knowledge through knowledge transfer. First consider the effect of an increase in ρ on local upstream firms' profits (the explicit formulations are relegated to Appendix B3):

$$\frac{d\Pi_u}{d\rho} = \frac{p_u}{\sigma}(\underbrace{IDL_2}_{<0} + \underbrace{PE_3}_{<0}) + \underbrace{KS_2}_{>0} \tag{3.14}$$

As before, there are three effects: An indirect demand linkage effect (IDL_2), a price effect (PE_3) and a knowledge spillover effect (KS_2). First, the indirect demand linkage takes effect as a result of an increase in knowledge transfer from the IJV to the local downstream firms. As they become more efficient, the derived input demand decreases, lowering upstream firms' profits. Moreover, the higher IPP (i.e. the higher θ), the more knowledge is transferred downstream and the larger the negative effect on Π_u. Second, and similar as before, the price effect occurs because knowledge spillovers to local upstream firms and knowledge transfer by the MNE to the IJV affect all firms in the upstream sector simultaneously. This lowers the price index P_U and thus also per firm revenue. Moreover, the extent to which knowledge spillovers add to this effect is larger the lower θ. Third, the knowledge spillover effect obviously increases upstream profits, and this effect becomes stronger the lower is θ.

Finally, for local downstream firms we now have (the explicit formulations are relegated to Appendix B4):

$$\frac{d\Pi_d}{d\rho} = \underbrace{PE_4}_{<0} + \underbrace{KT_2}_{>0} + \underbrace{FL_1}_{>0} \tag{3.15}$$

We can distinguish a price effect (PE_4), a knowledge transfer effect (KT_2) and a forward linkage effect (FL_1). The negative price effect occurs because all downstream firms are similarly affected by knowledge transfer and decreased input prices. That is, they all become more productive and charge lower prices, thus decreasing per firm revenue. Note that θ has an ambiguous effect on this mechanism: On the one hand, it magnifies the negative effect through increased knowledge transfer, but on the other hand it reduces it through decreased knowledge spillovers to upstream firms (and hence, a smaller decrease in input prices). The knowledge transfer effect obviously increases downstream firm profits, and the more so the higher is θ. Finally, the forward linkage effect occurs because knowledge spillovers from the IJV to local upstream firms, as well as knowledge transfer from the MNE to the IJV, decrease input prices for downstream firms, thus increasing their profits. In this case, an increase in θ has an unambiguously negative effect, as it serves to decrease knowledge spillovers.

3.3.3 Signing the effects

All total derivatives derived contain effects that are opposite in sign. Moreover, as can be seen from the expressions in the Appendix, deriving conditions under which their sign is unambiguous is not straightforward for most of these derivatives. A lot of this ambiguity is caused by the often opposing effects of IPP (θ). Indeed, as it turns out, many of the expressions simplify substantially when considering the extreme cases, i.e. when $\theta = 0$ or $\theta = 1$. In Table 3.1 below we summarize the signs of the total derivatives, also considering the cases in which $\theta = \{0, 1\}$. The derivations can be found in the relevant Appendices. After deriving the signs of the various expressions, we will empirically explore the insights regarding the horizontal and vertical effects of MNE ownership on local firms in the remainder of the chapter. Moreover, the cross-country nature of our firm panel also allows us the empirically investigate the derived effects of differences in IPP.

First consider the effects through backward linkages, i.e. $d\Pi_u/d\rho$ with MNEs downstream in (3.12). When θ is variable or when $\theta = 0$, the effect of a change in ρ on upstream profits is indeterminate in (3.12). However, given that the conditions in Table 3.1 are met, the effect is unambiguously positive for $\theta = 1$. Obviously, $\theta = 1$ indicates perfect IPP and upstream knowledge transfer by the MNE is at its maximum, *ceteris paribus* maximizing the positive effect of KT_1 in (3.12). Moreover, the condition implies that the positive effect is more likely (i) the smaller are total variable costs relative to total fixed costs in the downstream industry (the LHS of the condition), (ii) the larger is α and (iii) the larger is η. The latter effect is caused by the fact that a higher η - implying a more price-sensitive demand for downstream products - translates the downstream price decrease (due to a decrease in P_U following increased knowledge transfer) into higher demand for downstream products, and thus also higher derived demand for upstream intermediates. This effect in turn is larger, the larger is the intermediate input share of downstream firms α. The first effect occurs through the backward demand linkage BL_1: since downstream fixed costs are only affected through knowledge spillovers,

Table 3.1: Signs of the total derivatives

		$0 \leq \theta \leq 1$	$\theta = 0$	$\theta = 1$
MNEs downstream	$\frac{d\Pi_u}{d\rho}$	$\gtreqless 0$	$\gtreqless 0$	> 0 if $\frac{(n_{IJV}\beta_{IJV}x_{IJV}+n_d\beta_d^S x_d)}{(n_{IJV}F_{IJV}+n_d F_d^S)} < -\frac{\alpha(1-\eta)P_U+(1-\alpha)w}{\alpha P_U+(1-\alpha)w}$
	$\frac{d\Pi_d}{d\rho}$	$\gtreqless 0$	> 0	> 0
MNEs upstream	$\frac{d\Pi_u}{d\rho}$	$\gtreqless 0$	> 0 if $\frac{\sigma}{\sigma-1} < \frac{[(F_m-F_d)+x_u(\beta_m-\beta_n)]}{x_u(\beta_m-\beta_n)}$	< 0
	$\frac{d\Pi_d}{d\rho}$	> 0 if $\varepsilon > 2$	> 0 if $\varepsilon > 2$	> 0 if $\varepsilon > 2$

whereas marginal costs both through knowledge spillovers and price effects, the total negative effect on upstream firms of these combined effects will be lower, the smaller are variable costs relative to fixed costs.

Next consider the effects through forward linkages, i.e. $d\Pi_d/d\rho$ with MNEs upstream in (3.15). The table shows that in all cases, $\varepsilon > 2$ is a sufficient condition for this derivative to be positive. The reason for this is that although the negative price effect PE_4 in (3.15) becomes more severe when downstream products become better substitutes (i.e. when ε is higher), at the same time also the positive impact of both KT_2 and FL_1 are relatively more pronounced; the resulting downstream price decreases that follow from them have a larger impact on firm profits when ε is higher. These two positive effects consistently outweigh the negative effect of PE_4 when $\varepsilon > 2$.

Finally, in order to consider the intra-industry effects of a change in ρ, we have to consider both $d\Pi_d/d\rho$ with MNEs downstream, as well as $d\Pi_u/d\rho$ with MNEs upstream. In our model, we have looked at these two cases separately, but in reality MNEs will simultaneously serve as downstream (customer) firms for some local companies, and as upstream (supplier) firms for others. First consider $d\Pi_d/d\rho$ with MNEs downstream: We see that in both the extreme cases ($\theta = 0, 1$) its sign is unambiguously positive. The reason is that in both cases, one of either two positive effects in (3.13) is maximized, which more then compensates the remaining negative effect of PE_2. Specifically, when $\theta = 0$, KS_1 is maximized and when $\theta = 1$, IDL_1 is maximized. For $d\Pi_u/d\rho$ with MNEs upstream, we see a conditional positive effect when $\theta = 0$ and an unconditional negative effect when $\theta = 1$. The latter is obvious: If $\theta = 1$, KS_2 in (3.14) is zero, so that only the negative effects of IDL_2 and PE_3 remain. When $\theta = 0$, the negative effect of IDL_2 disappears and the effect of KS_2 is maximized. The condition states that the larger fixed costs are relative to marginal costs (or more precisely: the more important the effect of knowledge diffusion on fixed rather than marginal costs) the more likely it is that $d\Pi_u/d\rho > 0$. The reason is that the negative price effect PE_1 only works through marginal costs, whereas the positive knowledge spillover effect KS_2 works both through fixed and marginal costs. Taken together, these effects imply that horizontal (intra-industry) effects of increasing ρ are positive if $\theta = 0$ and fixed costs are large relative to marginal costs, whereas they are ambiguous if $\theta = 1$.

3.4 Data and methodology

3.4.1 Method

Although our theoretical model derives predictions regarding the relationship between firm profits and MNE ownership, the extant literature on knowledge diffusion from FDI usually considers the effect of MNE presence on local firms' productivity. In order to enhance comparability of our results, we also follow this approach in the empirical section of the paper. Moreover, from the profit functions in Section 3.2 it is clear that there exists a positive and proportional relationship between firm productivity and firm profits.

The empirical model that we will estimate takes a form similar to model 2.2 in Chapter 2:

$$\begin{aligned} y_{ijkt} &= \beta_0 + \beta_1 Horizontal_{jkt} + \beta_2 Backward_{jkt} + \beta_3 Forward_{jkt} \\ &\quad + \boldsymbol{\beta}_4 \mathbf{X}_{it} + D_j + D_k + \varepsilon_{ijkt} \end{aligned} \tag{3.16}$$

where i, j, k and t index firm, industry, country and time (year) respectively, y is firm level productivity, $Horizontal$ is a measure of intra-industry MNE presence, $Backward$ $(Forward)$ is a measure of MNE presence in customer or downstream (supplier or upstream) industries, $\mathbf{X}$ is a vector of firm level control variables, D_j and D_k are two sets of industry and country dummies, ε is an error term which is clustered at the industry level and assumed to be normally distributed, and the β's are the parameters to be estimated. The precise measurement of these variables is explained below.

A well-known problem with empirical models such as the one in (3.16) is the measurement of the dependent variable. Productivity is usually computed as the error term of a production function. However, to the extent that (expected) changes in productivity are observed or anticipated by firms' managers, the requirement of independence between the error term and the independent variables is violated, since managers may adjust variable inputs and production factors (such as labor) in anticipation of productivity changes.

Olley and Pakes (1996) suggest a robust estimator to tackle this issue. The underlying idea is that there exists a relationship between unobserved productivity on the one hand, and observable investment and capital on the other hand. Using this relationship, one can control for productivity in the production function estimation, by adding the function of investment and capital in addition to labor and capital (and material) inputs.[22] Levinsohn and Petrin (2003) extend this approach to situations in which there are a lot of zero observations on firm level investment, in which case it is not possible to invert the investment function, and hence to derive the productivity function. Since virtually all of our firms have positive observations on investment, we will use the Olley and Pakes (1996) procedure to estimate productivity.[23]

One important additional issue we need to tackle is the fact that our theoretical model does not suggest a clear functional form regarding the relationship between MNE ownership in its subsidiary and local firm profits (and productivity). This can be noted from the expressions of the total derivatives (*cf.* Appendix), which themselves are polynomial functions of MNE ownership ρ. Moreover, the degree of the polynomial in ρ depends on the elasticities of substitution and demand. A second issue in this regard is that some parameters in our model may be functions of ρ themselves, such as the different elasticities of substitution or the input and output shares, which further induces the different total derivatives to be (polynomial) functions of ρ. Hence it would be inappropriate to specify a functional form empirically *ex ante.* Fortunately, we can use (semiparametric) partial linear regression analysis to get a clue regarding the proper empirical specification.

Specifically, the generic partial linear regression model in our case takes the following form:

$$y_i = g(z_j) + \gamma \mathbf{X}_i + D_j + D_k + \eta_i \tag{3.17}$$

where i and j again index firm and industry respectively, $g(z)$ is the nonparametric component of the model for which the functional form is determined using a Kernel estimator, $\mathbf{X}$ is a vector of (firm level) variables that enter the model in the usual parametric fashion, and η is an error term. In the context of the present paper, the $Horizontal$, $Backward$ and $Forward$ variables would enter the non-parametric component, whereas the control variables enter the parametric component.

The model in (3.17) can be estimated by using a difference estimator (Robinson, 1988). Lokshin (2006) proposes the following estimator of the

[22] Since the appropriate functional form of the function of investment and capital is not known, Olley and Pakes (1996) use a third-order polynomial expansion in both variables to proxy the function. We follow this procedure in our production function estimation.

[23] In order to empirically implement the estimator, we use a program developed by Arnold (2003).

model, based on Yatchew (1997), where the observations are ordered as $z_1 < z_2 < .. < z_N$:

$$\sum_{k-1}^{m} d_k y_{i-k} = \sum_{k-1}^{m} d_k g(z_{i-k}) + \gamma \left(\sum_{k-1}^{m} d_k \mathbf{x}_{i-k} \right) + \sum_{k-1}^{m} d_k \eta_{i-k} \tag{3.18}$$

where m is the order of differencing and the d's are the differencing weights.[24] When optimal weights d are chosen, OLS estimation can be consistently applied to (3.18) in order to obtain estimates for the parametric part of the model. If we denote the resulting estimator by $\hat{\gamma}_{diff}$ we can retrieve the nonparametric component in (3.17) as follows:

$$y_i - \hat{\gamma}_{diff} x_i = g\left(z_j\right) + (\gamma - \hat{\gamma}_{diff})\mathbf{X}_i + \eta_i \simeq g(z_j) + \eta_i$$

We can then use a nonparametric estimator to estimate the nonparametric component $g(z_j)$. Here we again follow Lokshin (2006) who proposes the use of a Locally Weighted Scatterplot Smoother (lowess). Lowess belongs to the class of Nearest Neighbors Estimators: it estimates local polynomials to derive a functional form for $g(.)$, based on the distribution of the observations in a zy-scatterplot. The local polynomial estimation is repeated over small parts of the distribution, where the partitioning (in so-called bandwidths) is variable. This results in a smoothed fit of the relationship between z and y, which can be depicted in zy space.

Finally, we need a way to determine whether or not the nonparametric component in (3.17) makes a significant contribution to the model. Obviously, since we are not estimating any parameter values, we cannot use regular test statistics to determine significance. Instead, Lokshin (2006) proposed the following test statistic:

$$V = \sqrt{mN}(s^2_{res} - s^2_{diff})/s^2_{diff} \quad \sim \mathrm{N}(0,1) \tag{3.19}$$

where s^2_{res} is the mean square residual of the parametric regression and s^2_{diff} the squared residual of the semi-parametric regression. Hence, if this test statistic surpasses the standard normal critical values at usual significance

[24] These weights have to satisfy two conditions: (i) $\sum_{k-1}^{m} d_k = 0$, which assusres that the nonparametric component in (3.17) is removed since $g(\cdot)$ is assumed to be smooth, single-valued and to have a bounded first derivative; (ii) $\sum_{j-1}^{m} d_j^2 = 1$ which assures that the residuals in (3.17) have variance σ^2_η.

levels, we can conclude that the nonparametric component contributes significantly to the model in (3.17).

Despite the attractive property of not having to specify an explicit functional form between productivity effects and MNE ownership, there are some other caveats of partial linear regression analysis. The most important of these is that the method of Lokshin (2006) is only applicable to cross-section samples, so that we loose a lot of information contained in the time-series dimension of the data. The second drawback is that this method does not allow for clustering of the error term, which is problematic when estimating firm-level productivity effects while using firm and sector level explanatory variables. Third, because of the need for a fairly large sample to consistently estimate the partial linear model (the so-called *curse of dimensionality* in semiparametric and non-parametric regression analysis), it is unwarranted to split up the sample according to IPP levels, as this would heavily reduce the size of the resulting subsamples. Because of these drawbacks, we use the semiparametric approach mainly for exploratory purposes, and revert to a more standard parametric specification to tackle these three issues.

Summarizing, in order to obtain a proper estimate of our dependent variable in model (3.16) we use the Olley and Pakes (1996) procedure. Moreover, since we have no clear theoretical indications regarding the proper functional form of the relationship between firm productivity and MNE ownership, we use semiparametric regression analysis to find the best parametric specification for this relationship. We will then take the functional forms suggested by the partial linear regression models and impose it in a standard parametric regression model like the one in (3.16).

3.4.2 Data

Our sample contains a short panel of 1,549 large, publicly traded firms that are active in 20 countries and 18 sectors during the period 2000-2005. Of these firms, 327 are partly owned by a foreign company.[25] In order to obtain the production function parameters with the Olley and Pakes (1996) procedure, we estimated production functions at the two-digit ISIC Rev. 3 level. A full list of countries and sectors is included in the Appendix.

Our main variable of interest, i.e. the extent of intra-industry MNE

[25] We thank Radislav Semenov for collecting and cleaning a large part of the ownership data. More information on these data can be found in De Jong and Semenov (2006).

presence, is computed as follows (*cf.* Javorcik, 2004a):

$$Horizontal_{jt} = \frac{\sum_{i=1}^{n_j}(\rho_i \times Sales_{it})}{\sum_{i=1}^{N_j} Sales_{it}} \quad \text{s.t. } 0 \leq \rho_i < 1 \tag{3.20}$$

where n_j is the number of foreign-owned subsidiaries present in sector j, N_j is the total number of firms in sector j, ρ_i is the share of MNE ownership in the subsidiaries, and $Sales_i$ are the amount of firm-level sales. As with most empirical studies using MNE ownership, we only have observations for ρ in one year (2004), which we also use to compute $Horizontal$ in the other years.

In line with Javorcik (2004a), we use input and output shares (constructed from OECD I-O tables) to compute forward and backward linkages.[26] Specifically, if α_{jk} denotes the output share of sector j flowing to sector k (with $j \neq k$) backward linkages are computed as:

$$Backward_{jt} = \sum_{k \neq j}(\alpha_{jk} \times Horizontal_{kt}) \tag{3.21}$$

where $Horizontal_{kt}$ is defined as in (3.20). Hence, in line with the theoretical model developed in Section 3.2, the extent of backward linkages is proxied by the amount of inter-industry sales from industry j to k.

Forward linkages are computed in an analogous manner:

$$Forward_{jt} = \sum_{j \neq k}(\mu_{jk} \times Horizontal_{kt}) \tag{3.22}$$

where μ_{jk} is the share of inputs that sector j obtains from sector k. Javorcik (2004a) nets out exports from the host country to other countries from $Horizontal_{kt}$ in this case, since such exports are obviously not destined for local sector j. However, due to lack of data we are not able to follow this approach, and have to settle with the computation in (3.22) (see Chapters 4 and 5 for an explicit treatment of this issue).

As explained in the previous section, our dependent variable is the (log of) productivity of local firms, computed using the Olley and Pakes (1996) methodology, and using data on net sales and revenue, employment, net

[26] Although our data pertain to the period 2000-2005, the most recent I-O tables available are from 2002, so that we use these data to compute input-output shares for the entire period.

Table 3.2: Pairwise correlations

	1	2	3	4	6	7
1. (Log) Productivity						
2. Horizontal	0.15					
3. Backward	0.16	0.16				
4. Forward	0.17	0.39	0.22			
6. (Log) Size	0.17	-0.04	0.08	-0.00*		
7. Market share	0.18	0.07	0.11	0.04	0.52	
Mean	5.03	4.40	0.50	1.46	12.8	0.07
St. Dev.	1.88	8.66	0.77	3.65	1.87	0.14

Notes: * correlation is insignificant $p < .05$

fixed capital stocks and total investment for the years 2000-2005. The log of this variable was taken since the distribution of productivity across firms is heavily skewed.

We add two control variables: First, we use a measure of firm size, measured by (the log of) total assets of the firm (the log of this variable was taken since the distribution of total assets across firms is heavily skewed). The expected sign of this variable is unclear: Some authors have argued that large firms are conducive to innovation and hence productivity, because of economies of scale (Cohen and Klepper, 1996). Yet others argue that resources are not easily and efficiently allocated in large firms, hence wasting productive resources and decreasing productivity (Acs and Audretsch, 1990). The sign of this variable is thus an empirical matter. Second, in order to also incorporate a relative measure of firm size, we use the share of firm-sales in total industry-sales (i.e. market share) as an additional control variable. Again, the sign of this variable is not clear *ex-ante*. Table 3.2 presents some summary statistics and pairwise correlations between the variables.

We also have to construct variables that enable us to test the conditions in Table 3.1. For this purpose, we follow earlier research (Javorcik, 2004b; Allred and Park, 2007) and use the Ginarte and Park (1997) dataset containing data on the strength of national IPP systems.[27] The most recent set of observations relate to the year 2000, which are the ones we have used in the empirical part of the paper. The IPP index consists of five different components, all rated on a 0 to 1 scale (*cf.* Ginarte and Park, 1997 for a detailed description of this index). Taken together, the IPP index is measured along a 5 point scale, where a value of 0 indicates very weak IPP and 5 indicates very strong IPP.

Regarding the horizontal productivity effects, we noted that they are more likely to be positive under $\theta = 0$ when fixed costs make up a relatively large share of total costs (i.e. fixed and variable costs). We use data on net fixed assets F (property, plant and equipment) to capture firm-level fixed costs, and data on salaries and benefit expenses L to capture variable costs. We then construct a variable $(F + L)/L$ which corresponds with the condition in Table 3.1.[28]

For forward productivity effects ($d\Pi_d/d\rho$ with MNEs upstream) we established that if the elasticity of substitution ε between downstream products is large enough, this effect will be positive. If we interpret ε as a measure of downstream competition (with higher ε indicating more substitution and hence more competition) we can construct a Herfindahl index to measure the inverse of ε. Hence, for each country-industry-year combination in our sample, we construct a Herfindahl index which captures all our sample-firms which belong to a particular sector. The values of this index vary between 0.05 and 1 in our sample.

Finally, the condition regarding backward productivity effects ($d\Pi_u/d\rho$ with MNEs downstream) depends *inter alia* on α and η. α is already incorporated in the computation of (3.21). Since we do not have the data to compute proper estimates of η, we will just focus on α in the empirical part of the paper.

[27] We thank professor Park for sharing the updated dataset.

[28] Concerns could arise about multicollinearity between firm size (proxied by total assets) and our variable proxying cost structure (as it is partly composed by net fixed assets). Further inspection reveals an (insignificant) correlation of -0.00.

Table 3.3: Semiparametric model esimates

	(1) Horizontal	(2) Backward	(3) Forward
(log) Size	0.124***	0.163***	0.162***
	(.042)	(.025)	(.023)
Market Share	0.634*	0.387**	0.280*
	(.397)	(.160)	(.156)
V	2.85***	2.61***	2.67***
Industry dummies	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes
Adj R^2	0.29	0.53	0.52
N	1,195	2,462	2,462

Dependent variable is log of firm productivity. Notes: (a) * p<0.1; ** p<0.05; *** p<0.01; (b) Estimator based on Lokshin (2006) with 1st-order differencing. V is the test-statistic in (3.19), indicating the significance of the non-parametric model component.

3.5 Empirical results

3.5.1 Semiparametric results

Before turning to the regression results, we first briefly consider the productivity difference between local firms and IJVs, since the presumed productivity superiority of MNEs and hence IJVs vis-à-vis local firms lies at the heart of our model, and as such at the hart of the knowledge diffusion process. Comparing the log of productivity levels of the 327 IJVs in our sample versus the 1,222 local firms, the former have an average productivity of 5.80 and the latter of 5.02. A paired t-test strongly rejects the equality of these two means ($t = 14.3$). Hence, the superiority of IJVs with respect to local firms on productivity as assumed in our theoretical model is confirmed in our sample.

First we consider the results of the semiparametric partial linear regression model. We will investigate the effect of the three different MNE presence variables separately, in order to obtain the empirical functional relationship between productivity and the relevant MNE ownership share. As explained in the previous section, the partial linear regression estimator we use is only applicable in cross-sections. Thus all results reported in this subsection pertain to the year 2004, which is the year in which the MNE ownership shares were observed. The results of the partial linear regression model are reported in Table 3.3. Figure 3.2 contains the resulting non-parametric relationship between productivity and each of the MNE presence variables.

The first column in Table 3.3 adds the horizontal variable from (3.20) to the non-parametric component of the model. As indicated by the test statistic V from (3.19), the non-parametric component enters the model highly significantly. Panel (a) in Figure 3.2 depicts the implied relationship. We find that an increase in MNE ownership in the IJV increases local firms' productivity. However, it is also clear that this relationship is not linear, but characterized by decreasing returns to MNE ownership at low levels of MNE ownership, and increasing returns to MNE ownership at high levels. Hence, the semiparametric model suggests a cubic relationship between intra-industry MNE ownership and local firms' productivity.[29]

In the second column we put the backward variable from (3.21) in the non-parametric component. The test statistic V again indicates that the non-parametric component enters the model highly significantly, and panel (b) in Figure 3.2 depicts the relationship between the downstream MNE ownership share and upstream local firms' productivity. The figure demonstrates a quadratic relationship, although the 95% confidence interval around this relationship is quite large.

Finally, in column three of Table 3.3 we put the forward variable from (3.22) in the non-parametric component of the model. Forward spillovers enter the model highly significantly and from panel (c) in Figure 3.2 we see that the relationship between upstream MNE ownership and downstream productivity of local customers is again characterized by a quadratic relationship. But also in this case, the 95% confidence interval is rather wide.

Both firm size and market share are significant and positive, indicating that both absolute firm size as well as firm size relative to the market are conducive to productivity. In terms of model fit, the models perform rather

[29] In the parametric setup in the next section, we also experimented with a piecewise linear regression model, with breakpoints around 5% and 35% of MNE ownership, as suggested by panel (a) in Figure 3.2. The results were clearly outperformed by a cubic specification both in terms of significance and fit.

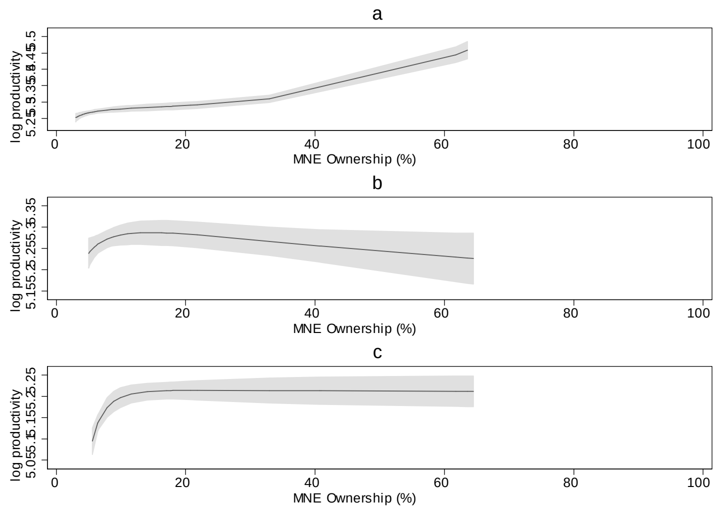


Figure 3.2: Semiparametric relationship between firm productivity and MNE ownership

well, indicating that the industry and country fixed effects also absorb a lot of the variation in firm productivity (i.e. the relatively high R-squares in the models are not solely induced by the three regressors). However, in order to tackle the three problems described in the previous section, we have to revert to parametric regression analysis. In doing so, we can use the outcomes of the semiparametric models as a guide regarding the parametric model specification. Specifically, the semiparametric results suggest that we need quadratic and cubic specifications to capture the relationship between firm productivity and MNE ownership. Hence, we construct two new variables:

$$Horizontal^2_{jt} = \frac{\sum_{i=1}^{n_j}(\rho_i^2 \times Sales_{it})}{\sum_{i=1}^{N_j} Sales_{it}} \quad \text{s.t. } 0 \leq \rho_i < 1 \tag{3.23}$$

$$Horizontal^3_{jt} = \frac{\sum_{i=1}^{n_j}(\rho_i^3 \times Sales_{it})}{\sum_{i=1}^{N_j} Sales_{it}} \quad \text{s.t. } 0 \leq \rho_i < 1 \tag{3.24}$$

These two variables - in combination with $Horizontal$ from (3.20) - should be able to capture the intra-industry productivity effects in a parametric setup. Using these, we can also construct two additional variables to parametrically proxy the quadratic relationship between downstream (upstream)

MNE ownership and upstream (downstream) productivity:

$$Backward_{jt}^{2} = \sum_{k \neq j} (\alpha_{jk} \times Horizontal_{kt}^{2}) \tag{3.25}$$

$$Forward_{jt}^{2} = \sum_{j \neq k} (\mu_{jk} \times Horizontal_{kt}^{2}) \tag{3.26}$$

3.5.2 Parametric results

Table 3.4 below specifies parametric regression models, including all three diffusion variables, as well as the two control variables, while exploiting both the cross-section and the time variation of the data and splitting up the sample in high and low IPP countries in columns (2) and (3). The standard errors are robust and have been allowed to cluster at the industry level.[30]

The results for the total sample in the parametric model are reported in column (1) and are rather different from the semiparametric results. Regarding the horizontal productivity effects, instead of a cubic relationship we actually observe a squared relationship. Specifically, there appear to be decreasing returns to MNE ownership, as depicted in panel *a* of Figure 3.3:[31] after an initial increase in intra-industry productivity effects following an increase in ρ, the relationship becomes negative around 30% of MNE ownership. Regarding the backward and forward effects, none of them are significant.

[30] An alternative to this specification would be to cluster standard errors at the country level. By choosing to cluster at the industry-level rather than the country-level, we implicitly assume that any shocks in the error term of the model are more likely to simultaneously affect firms wihtin the same industry than firms within the same country. We also tried clustering the standard errors at the country-level, but most of the results became insignificant in that case. A third strategy that we pursued was to cluster standard errors at the industry×country-level. Although this leaves most of the results below intact, the coefficients are less precisely estimated.

[31] All the panels in Figure 3.3 are constructed with generic formulas $y = (ax + bx^2 + cx^3) \cdot z$, where y is productivity, x is MNE ownership (between 0 and 100) and z is the mean value of either $Horizontal$, $Backward$ or $Forward$, computed without correcting for MNE ownership shares (these are 0.1, 0.01 and 0.03 respectively). The coefficients a, b and (if applicable) c are the coefficient estimates from Table 3.4.

Table 3.4: Parametric model esimates

	(1) Total Sample	(2) Low IPP	(3) High IPP
Horizontal	0.047**	0.100*	0.057**
	(.017)	(.053)	(.022)
Horizontal Squared	−0.001**	−0.004**	−0.001**
	(.001)	(.002)	(.001)
Horizontal Cubed (× 100)	0.000	0.002**	0.000
	(.000)	(.001)	(.000)
Backward	0.168	0.014	0.420**
	(.146)	(.340)	(.203)
Backward Squared	−0.003	0.001	−0.008***
	(.002)	(.004)	(.003)
Forward	0.004	−0.087	0.100
	(.073)	(.058)	(.220)
Forward Squared	0.000	0.001	−0.002
	(.001)	(.001)	(.004)
(log) Size	0.205***	0.183**	0.206***
	(.050)	(.076)	(.046)
Market Share	0.847***	1.24**	0.785**
	(.265)	(.492)	(.359)
Constant	0.138	−1.60	2.74***
	(.643)	(.847)	(.574)
Industry dummies	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes
R^2	0.79	0.78	0.79
N	6,579	1,855	4,724

Dependent variable is log of firm productivity. Notes: (a) * p<0.1; ** p<0.05; *** p<0.01; (b) Robust standard errors with industry-level clustering; (c) Low IPP < 4.19 on Ginarte and Park (1997) index.

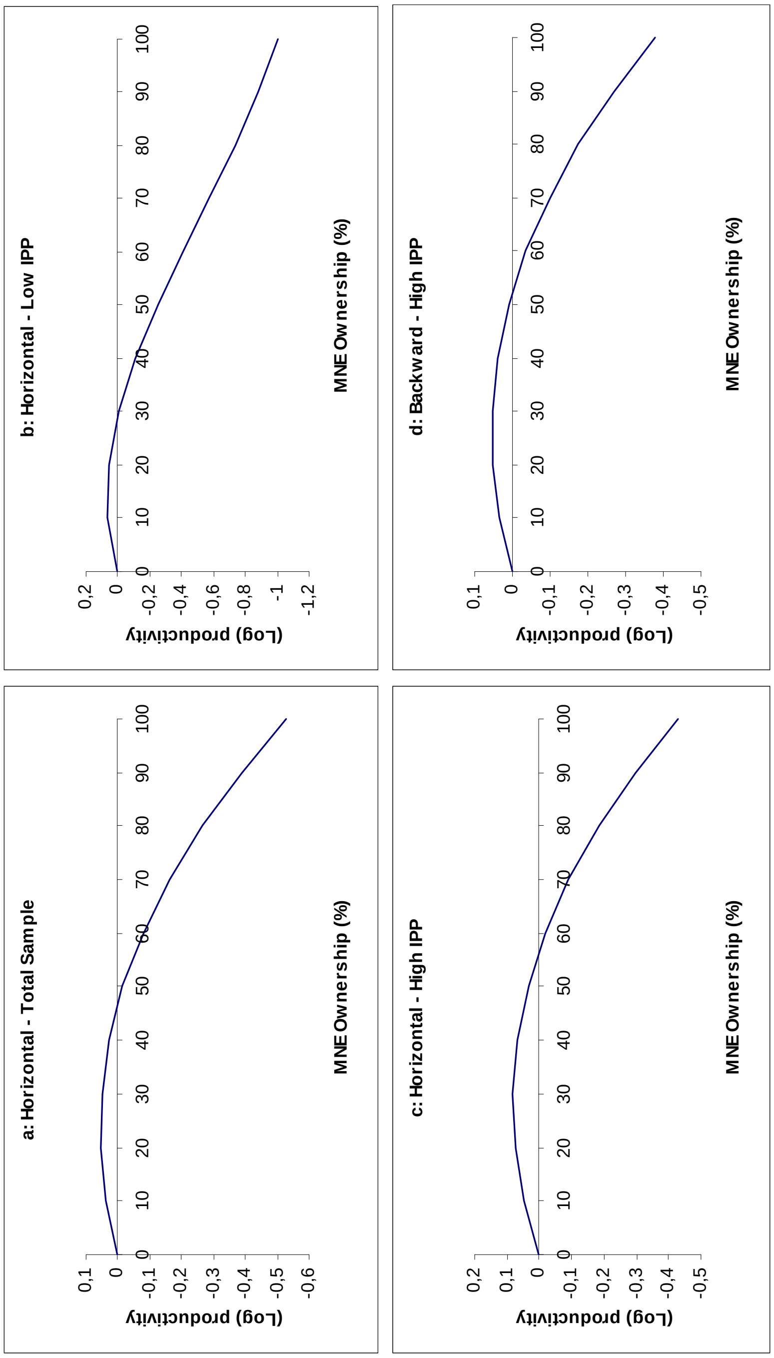


Figure 3.3: Parametric relationship between firm productivity and MNE ownership

We proceed by splitting up the sample in two groups: those with a relatively high IPP index and those with a relatively low IPP index. We use the median IPP level in the total sample as the cutoff point: this level is 4.19.[32] Column 2 in Table 3.4 presents the result for the low-IPP sample. In contrast to the total sample results in column (1), we now observe a cubic relationship between MNE ownership and intra-industry productivity effects. As shown in panel b of Figure 3.3, between 0%-20% of MNE ownership there is a positive relationship with intra-industry productivity effects, but this becomes negative after 20%. The subsequent decline in total productivity is larger than in the total sample. The minimum in this relationship is beyond the relevant domain (i.e. the minimum of the function in panel 3.3b lies beyond 100% MNE ownership). As before, both the backward and forward effects are insignificant.

Column (3) in the table repeats this model for the high-IPP countries. The horizontal productivity effects change back to a quadratic form, with the turning point from a positive to a negative relationship at 55% (panel c of Figure 3). We now also observe significant backward productivity effects, for which there appear to be decreasing returns to MNE ownership as well. As shown in panel d of Figure 3, the turning point of the relationship lies around 30%. Also note that the backward effect is similar in magnitude as the horizontal effect.

Both control variables are significant as in the semiparametric regressions. Firm size is consistently positive, indicating that larger firms are more productive, and market share is consistently positive as well, indicating that large firm size relative to market size is generally also conducive to firm productivity. Regarding model fit, all three models perform rather well with R^2s around 80%.

In Table 3.5 we repeat these regressions, now taking into account the conditions derived in Table 3.1. Specifically, for all three regressions we interact the forward variable with a Herfindahl index. Additionally, in the low IPP sample we interact the horizontal variable with our $(F+L)/L$ variable. As mentioned before, the effect of α on the backward variable is already

[32]Note that this median value pertains to the country-level rather than the industry or firm-level, so that the number of (firm-year) observations is not equally split between the two groups. Admittedly, a median value of 4.19 is rather high, which is caused by the fact that we have mainly high-developed countries in our sample. Also, it implies that the variation in IPP is much higer in the low-IPP sample (from 2.9 to 4.19) than in the high-IPP sample (from 4.19 to 5).

included by construction. For reasons of space, we do not report the control variables (and the constant) but note that their coefficient estimates are similar to those in Table 3.4.

Column (1) shows that the horizontal productivity effects are virtually similar as in column (1) of Table 3.4. However, we now also observe significant effects of our forward variable, interacted with the Herfindahl index. Panel a of Figure 3.4 shows the individual forward productivity effect: the relationship is positive up to 50% of MNE ownership and then becomes negative. Panel b depicts the interacted relationship, where we have taken the extreme case (i.e. a Herfindahl index of 1). As can be seen, the effects are almost reversed now, with a negative relationship up to 40% of MNE ownership.

In column (2) we also interact the horizontal variable with $(F + L)/L$. Both the individual and interacted effects are highly significant. Panel c in Figure 4 shows the individual effects, which differ heavily from those in panel b of Figure 3.3. In this case, the relationship is positive for MNE ownership below 30% and above 60%, and negative in between. In stark contrast, the interacted effects shown in panel d of Figure 3.4 demonstrate a consistently negative relationship between MNE ownership and intra-industry productivity.[33] Regarding the forward effects, we now only observe a significant effect of the interaction terms. The effects are similar to those in panel b of Figure 3.4, although the turning point now lies around 50%.

[33] The variable $(F+L)/L$ was evaluated at its mean of 14 when constructing the graph.

Table 3.5: Parametric model esimates - Interactions

	(1) Total Sample	(2) Low IPP	(3) High IPP
Horizontal	0.046^{**}	0.145^{**}	0.061^{**}
	(.018)	(.062)	(.020)
Horizontal $\times$ $[(F+L)/L]$	-	-0.014^{***}	-
		(.004)	
Horizontal Squared	-0.001^{*}	-0.004^{**}	-0.001^{***}
	(.001)	(.002)	(.000)
Horizontal Squared $\times$ $[(F+L)/L]$	-	0.0004^{***}	-
		(.0001)	
Horizontal Cubed ($\times$ 100)	0.000	0.003^{**}	0.0006^{*}
	(.000)	(.001)	(.0003)
Horizontal Cubed $\times$ $[(F+L)/L]$ ($\times$ 100)	-	-0.0003^{***}	-
		(.0001)	
Backward	0.147	-0.183	0.437^{**}
	(.147)	(.375)	(.192)
Backward Squared	-0.003	0.011^{*}	-0.009^{***}
	(.002)	(.006)	(.003)
Forward	0.189^{*}	0.274	0.466^{*}
	(.102)	(.255)	(.263)
Forward $\times$ Herfindahl	-0.550^{***}	-1.15^{**}	-1.05^{***}
	(.146)	(.506)	(.326)
Forward Squared	-0.002^{*}	-0.003	-0.008
	(.001)	(.003)	(.005)
Forward Squared $\times$ Herfindahl	0.007^{***}	0.013^{**}	0.016^{**}
	(.002)	(.006)	(.006)
Industry dummies	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes
R^2	0.79	0.80	0.79
N	6,579	1,404	4,724

Dependent variable is log of firm productivity. Notes: (a) * p<0.1; ** p<0.05; *** p<0.01; (b) Robust standard errors with industry-level clustering; (c) Low IPP < 4.19 on Ginarte and Park (1997) index.

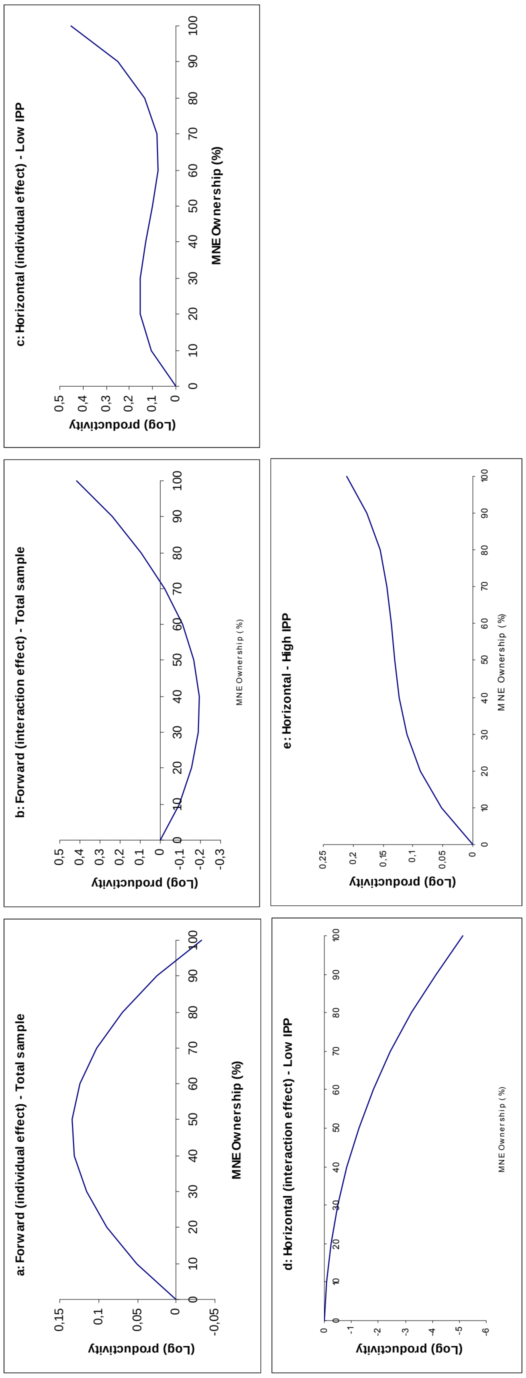


Figure 3.4: Parametric relationship between firm productivity and MNE ownership: Interaction effects

Finally, column (3) repeats the model in column (1) for the high IPP sample. In contrast to Table 3.5, there now is a cubic relationship between MNE ownership and intra-industry productivity, shown in panel e of Figure 3.4. The relationship is now positive over the entire domain, with decreasing returns to ρ up until 70%, after which there are increasing returns. As before, backward productivity effects are significant, showing a similar pattern as in panel c of Figure 3.3. The individual forward productivity effect is now linear and positive, whereas the interaction effect shows an effect similar to panel b in Figure 3.4, with the turning point at 20%. With R^2s of around 80% all the models perform well.

3.6 Discussion and conclusion

In this chapter we have theoretically and empirically investigated the relationship between horizontal and vertical productivity effects from MNEs with varying degrees of foreign ownership to local (host-country) firms. Theoretically, we have established the ambiguity in this relationship due to the simultaneous interplay of (sometimes) opposing knowledge diffusion, price and direct and indirect demand and supply linkage effects, and the mediating effect of intellectual property right protection (IPP). We have also distinguished between unintentional knowledge spillovers and intentional knowledge transfers, where we argue the former mainly occur intra-industry, whereas the latter dominate inter-industry knowledge diffusion. Eventually we derived a number of conditions under which some of the ambiguous productivity effects are more likely to be positive or negative.

We then empirically investigate the relationship between horizontal and vertical MNE ownership in foreign affiliates and local firms' productivity, using a panel of 1,222 local firms and 327 MNEs in 20 countries and 18 industries during the period 2000-2005. We utilize semiparametric partial linear regression analysis for exploratory purposes, and standard parametric panel data techniques to derive the empirical results.

Regarding horizontal (intra-industry) productivity effects, we initially find that there are decreasing returns to MNE ownership. I.e. although productivity effects first increase with MNE ownership, at some point the relationship becomes negative. From our theoretical model, we can derive that for low degrees of MNE ownership, the positive knowledge spillover and indirect upstream demand linkages dominate, whereas for increased degrees of MNE ownership, the negative price effect and indirect downstream demand linkages dominate. One implication is that increased MNE ownership affects input and output shares asymmetrically: it appears that local input demand decreases faster with increased MNE ownership than local output supply, which may cause the shift from positive indirect upstream demand linkages to negative indirect downstream demand linkages. Moreover, we observe that the optimum in the relationship between firm productivity and MNE ownership occurs at higher degrees of MNE ownership in high-IPP systems relative to low-IPP systems. This may be a reflection of the fact that MNE owners feel more secure in transferring knowledge upstream in high-IPP systems than in low-IPP systems, as we already conjectured in our theoretical setup.

However, these results change quite a bit when we consider the interaction effect between our measure of horizontal foreign presence and the inverse share of variable costs in total costs of local firms. Our theoretical model predicts that in low-IPP systems, an increase in this inverse share should increase the likelihood of positive productivity effects. The reason for this is that the negative price effect in our model only works through marginal costs, whereas the positive knowledge spillover effect works both through fixed and marginal costs. However, our empirical results reach exactly the opposite conclusion: for higher inverse shares (indicating a larger share of fixed costs in total costs), the productivity effects from increased MNE ownership are actually negative, whereas for lower inverse shares they are largely positive. The implication is that positive knowledge spillover (and upstream indirect demand linkage) effects work more through marginal or variables costs than through fixed costs. The fact that our model predicts exactly the opposite is due both to an assumption (i.e. that both fixed and marginal costs are affected equally by knowledge spillovers and transfers) as well as the Dixit-Stiglitz monopolistic competition setup (which makes prices a function of marginal costs only). Our empirical results indicate that these modelling artefacts may be at odds with reality.

Regarding backward productivity effects, our theoretical model demonstrates opposing positive effects of upstream knowledge transfer, and negative effects of upstream price effects. Additionally, there is an ambiguous effect of backward linkages. We also find that at least in high-IPP countries, an increase in the input share will increase the likelihood of a positive effect, as it serves to make the backward linkages positive and hence tilt the balance in favor of the positive effects. Our empirical results are very consistent with this prediction. Indeed, in none of the total sample or low-IPP sample results do we find significant backward productivity effects, indicating the theoretical ambiguity. However, in the high-IPP samples we find a consistently significant effect. Moreover, we again find decreasing returns to MNE ownership, with a positive relationship only for relatively low degrees of MNE ownership. If we link this result with the literature on international input sourcing by MNEs (Taveres and Young, 2006), this result is very consistent with our theoretical predictions: according to this literature, increased MNE ownership increases the extent to which a subsidiary sources its inputs internationally instead of locally, hence decreasing the (local) input share. According to our model, this would eventually induce a negative relationship between MNE ownership and backward productivity effects for larger degrees of MNE ownership, which is exactly what we observe.

Finally, our model indicates that in all cases, forward productivity effects will only take effect if there is a sufficient degree of downstream competition, the reason being that in that case positive forward linkages and knowledge transfer effects outweigh negative demand effects. Indeed, when we just consider forward productivity effects separately (i.e. without simultaneously considering downstream competition) we find no effects whatsoever. Only after interacting this effect with a Herfindahl index of downstream competition do we find consistently significant effects. The positive relationship between MNE ownership and forward productivity effects in a highly competitive context is most pronounced in the high-IPP sample, where the effect is positive and linear. In the low-IPP sample there essentially is no effect in this case, whereas the relationship in the total sample is quadratic, reaching an optimum around 50%. These results are thus partly in accordance with our theory. Regarding the effects in low-competitive environments, we indeed find a negative relationship between MNE ownership and forward productivity effects for low degrees of MNE ownership. Nonetheless, for a large range of MNE ownership degrees, the relationship is positive, contrary to what our model predicts. One possible explanation for this is that there exists a relationship between upstream MNE ownership and downstream competition, which we have not modelled, but which does not seem unlikely.

So what does all of this imply for the effectiveness and usefulness of a well-developed IPP system? One thing that both our model and our empirical results suggest, is that a strong IPP system stimulates the intentional inter-industry transfer of knowledge from MNEs to local firms, the extent of which depends on the amount of MNE ownership. Indeed, only in the high

IPP samples do we find significant and positive effects of backward productivity effects for low degrees of MNE ownership. Also for forward productivity effects, we find a positive relationship with MNE ownership in the high-IPP sample, given that downstream competition is sufficient. Even for horizontal productivity effects, we find an unconditional positive relationship with MNE ownership in high-IPP countries, which is again probably due to the increased willingness of intentional inter-industry knowledge transfer, inducing positive indirect demand linkage effects (although we cannot separate these empirically). In sum, it seems that developing well-functioning IPP regulations is only to the benefit of the country involved: even though firms (with a relatively large share of variable costs in total costs) in low-IPP countries may also benefit from positive horizontal productivity effects, the positive inter-industry effects are largely absent. This result corresponds to findings by Javorcik (2004b).

Finally, this study is characterized by some limitations, the most important of which is the fact that our sample only consists of large and publicly traded firms. As such, the results of this study cannot be readily generalized beyond the specific characteristics of our sample, and moreover, a direct comparison to most of the earlier empirical one-country studies is not possible either. However, a trade-off exists between encompassing multiple countries in the analysis, versus increasing the firm-sample beyond only the largest firms, which inhibits investigating country-level effects on the knowledge spillover or transfer process. Another limitation is the fact that our sample mainly contains developed countries, which translates into a limited variation on our IPP variable. Increasing the sample to include also (large and traded) firms from less developed countries and emerging markets would be a valuable extension of this study, again specifically with regard to investigating country-level determinants or moderators of the knowledge diffusion process. Additionally, some studies suggest a relationship between IPP on the one hand and the organization of foreign activities on the other. For example, Hagedoorn, Cloodt and Van Kranenburg (2005) find that when IPP is low, firms are more likely to engage in IJVs than in contractual relationships when partnering for R&D collaboration, in order to forestall appropriability problems. In our setup, the implication of these findings might be that MNEs tend to favor high ownership shares over low ones in low IPP host-countries, which might go some way in explaining e.g. the absence of any backward producitivy effects in our low IPP sample. Investigating the interplay between these relationships would be an interesting avenue for future research.

Appendix A

Here we consider the case in which the IJV (and its local competitors) are active in the upstream industries, supplying other local firms in downstream industries. That is, we now consider part B of Figure 3.1. This allows us to investigate the direct effect of demand and supply effects and knowledge diffusion through forward linkages (rather than indirectly, via backward linkages).

The analysis is very similar to the one in the main text considering part A of Figure 3.1. The upstream industry price index is now given by:

$$P_U = (n_u p_u^{1-\sigma} + n_{IJV} p_{IJV}^{1-\sigma})^{1/(1-\sigma)}$$

As before, demand for intermediate products (which will be derived below) is denoted by I so that applying Sheppard's lemma yields demand for individual upstream firms' products:

$$\begin{aligned} x_u &= p_u^{-\sigma} I P_U^{\sigma} \\ x_{IJV} &= p_{IJV}^{-\sigma} I P_U^{\sigma} \end{aligned}$$

Profit functions for upstream firms are given by:

$$\begin{aligned} \Pi_u &= p_u x_u - (F_u^S + \beta_u^S x_u) w \\ \Pi_{IJV} &= p_{IJV} x_{IJV} - (F_{IJV} + \beta_{IJV} x_{IJV}) w \end{aligned}$$

In this case, the upstream firm benefits from MNE knowledge diffusion through spillovers rather than transfers, since it is a direct competitor of the IJV. Substituting the individual demands and maximizing profits yields the equilibrium pricing conditions:

$$\begin{aligned} p_u &= \frac{\sigma \beta_u^S w}{(\sigma - 1)} \\ p_{IJV} &= \frac{\sigma \beta_{IJV} w}{(\sigma - 1)} \end{aligned}$$

In the downstream, the price index is given by:

$$P_D = (n_d p_d^{1-\varepsilon})^{1/(1-\varepsilon)}$$

As before, total demand for downstream products is denoted by $YP_D^{-\eta}$ so that we can derive demand for individual downstream products:

$$x_d = p_d^{-\varepsilon} Y P_D^{\varepsilon-\eta}$$

Downstream firm profits are expressed as:

$$\Pi_d = p_d x_d - (F_d^T + \beta_d^T x_d)(\mu P_u + (1-\mu)w)$$

where μ is the share of inputs that the downstream firm obtains from the upstream firms. Again note that in this case, the downstream firm benefits from knowledge diffusion through knowledge transfer rather than knowledge spillovers. Substituting demand into the profit function we can once more derive profit maximizing equilibrium prices:

$$p_d = \frac{\varepsilon \beta_d^T (\mu P_u + (1-\mu)w)}{(\varepsilon - 1)}$$

We can now also write down an explicit function for derived demand for intermediate inputs:

$$I = \mu n_d (F_d^T + \beta_d^T x_d)$$

Appendix B

B1 IJVs in the downstream sector - $d\Pi_u/d\rho$

First consider the elements of $d\Pi_u/d\rho$:

$$BL_1 \equiv \underbrace{(\frac{\partial I}{\partial F_{IJV}} + (1-\theta)\frac{\partial I}{\partial F_d^S})(F_m - F_n) + (\frac{\partial I}{\partial \beta_{IJV}} + (1-\theta)\frac{\partial I}{\partial \beta_d^S})(\beta_m - \beta_n)}_{\text{indirect knowledge spillover <0}}$$

$$\underbrace{+\frac{\partial I}{\partial x_{IJV}}\frac{\partial x_{IJV}}{\partial p_{IJV}}\left[\frac{\partial p_{IJV}}{\partial \beta_{IJV}}(\beta_m - \beta_n) + \frac{\partial p_{IJV}}{\partial P_u}\frac{\partial P_u}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^T}\theta(\beta_m - \beta_n)\right]}_{\text{downstream demand linkage >0}}$$

$$\underbrace{+\frac{\partial I}{\partial x_d}\frac{\partial x_d}{\partial p_d}\left[\frac{\partial p_d}{\partial \beta_d^S}(1-\theta)(\beta_m - \beta_n) + \frac{\partial p_d}{\partial P_U}\frac{\partial P_u}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^T}\theta(\beta_m - \beta_n)\right]}_{\text{downstream demand linkage >0}}$$

$$\underbrace{+\left(\frac{\partial I}{\partial x_{IJV}}\frac{\partial x_{IJV}}{\partial P_D} + \frac{\partial I}{\partial x_d}\frac{\partial x_d}{\partial P_D}\right)\left(\begin{array}{c} \frac{\partial P_D}{\partial p_d}\left[\begin{array}{c}\frac{\partial p_d}{\partial \beta_d^S}(1-\theta)(\beta_m - \beta_n) \\ +\frac{\partial p_d}{\partial P_U}\frac{\partial P_u}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^T}\theta(\beta_m - \beta_n)\end{array}\right] \\ +\frac{\partial P_D}{\partial p_{IJV}}\left[\begin{array}{c}\frac{\partial p_{IJV}}{\partial \beta_{IJV}}(\beta_m - \beta_n) \\ +\frac{\partial p_{IJV}}{\partial P_U}\frac{\partial P_u}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^T}\theta(\beta_m - \beta_n)\end{array}\right]\end{array}\right)}_{\text{downstream price effect <0}}$$

$$PE_1 \equiv \frac{\partial x_U}{dP_U}\frac{\partial P_u}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^T}\theta(\beta_m - \beta_n)$$

$$KT_1 \equiv -w\theta\left[(F_m - F_u) + x_u(\beta_m - \beta_n)\right]$$

Using the explicit expressions for the partial derivatives and collecting terms yields the following expression for $d\Pi_u/d\rho$:

$$\frac{d\Pi_u}{d\rho} = \underbrace{\left[\frac{w\beta_u^T x_u}{\sigma - 1}\cdot\frac{\alpha\left(n_{IJV} + (1-\theta)n_d\right)}{I} - w\theta\right]}_{\text{Term 1}}(F_m - F_n)$$

$$+\frac{w\beta_u^T x_u}{\sigma - 1}\underbrace{\left[\begin{array}{c}\frac{\alpha A_1}{\beta_{IJV}} + \frac{\alpha}{\beta_u^T}\left(A_1 + A_2\right)\frac{\alpha P_U\theta}{\alpha P_U + (1-\alpha)w} + \frac{\alpha A_2}{\beta_d^S}(1-\theta) \\ +\alpha(n_{IJV}x_{IV} + (1-\theta)n_d x_d) + \frac{\theta I}{\beta_u^T}\end{array}\right]}_{\text{Term 2}}(\beta_m - \beta_n)$$

where

$$A_1 \equiv (n_{IJV}\beta_{IJV}x_{IJV} + n_d\beta_d^S x_d)n_{IJV}(\varepsilon-\eta)\left(\frac{p_{IJV}}{P_D}\right)^{1-\varepsilon} - \varepsilon(n_{IJV}\beta_{IJV}x_{IJV})$$

$$A_2 \equiv (n_{IJV}\beta_{IJV}x_{IJV} + n_d\beta_d^S x_d)n_d(\varepsilon-\eta)\left(\frac{p_d}{P_D}\right)^{1-\varepsilon} - \varepsilon(n_d\beta_d^S x_d)$$

In order to sign the derivative, note that the first term in Term 1 is positive and the second negative, so that Term 1 has an ambiguous sign. It can be shown that $A_1 < 0$ as follows:

$$\begin{aligned}
A_1 &< 0 \Longleftrightarrow X n_{IJV}(\varepsilon-\eta)\left(\frac{p_{IJV}}{P_D}\right)^{1-\varepsilon} < \varepsilon(n_{IJV}\beta_{IJV}x_{IJV}) \\
&\Leftrightarrow \frac{\varepsilon-\eta}{\varepsilon} < \frac{n_{IJV}\beta_{IJV}x_{IJV}P_D^{1-\varepsilon}}{X n_{IJV}p_{IJV}^{1-\varepsilon}} \\
&= \frac{n_{IJV}\beta_{IJV}p_{IJV}^{-\varepsilon}YP_D^{\varepsilon-\eta}P_D^{1-\varepsilon}}{X n_{IJV}p_{IJV}^{1-\varepsilon}} \\
&= \frac{\beta_{IJV}YP_D^{1-\eta}}{X p_{IJV}} = \frac{\beta_{IJV}YP_D^{1-\eta}}{p_{IJV}(n_{IJV}\beta_{IJV}x_{IJV} + n_d\beta_d^S x_d)} \\
&= \frac{\beta_{IJV}YP_D^{1-\eta}}{p_{IJV}YP_D^{\varepsilon-\eta}(n_{IJV}\beta_{IJV}p_{IJV}^{-\varepsilon} + n_d\beta_d^S p_d^{-\varepsilon})} \\
&= \frac{\beta_{IJV}P_D^{1-\varepsilon}}{p_{IJV}(n_{IJV}\beta_{IJV}p_{IJV}^{-\varepsilon} + n_d\beta_d^S p_d^{-\varepsilon})} = 1
\end{aligned}$$

since $p_{IJV} = (\beta_{IJV}/\beta_d^S)p_d$. Since $\varepsilon > \eta$, this condition will always hold, and similarly for A_2. Moreover, this also implies that $A_1 + A_2 < 0$. Indeed, we have that:

$$A_1 + A_2 = -\eta(n_{IJV}\beta_{IJV}x_{IJV} + n_d\beta_d^S x_d) < 0$$

Note that we can rewrite Term 2 as follows:

$$\begin{aligned}
&\left[\begin{array}{c} \frac{\alpha A_1}{\beta_{IJV}} + \frac{\alpha}{\beta_u^T}\left(A_1 + A_2\right)\frac{\alpha P_U \theta}{\alpha P_U + (1-\alpha)w} + \frac{\alpha A_2}{\beta_d^S}(1-\theta) \\ +\alpha(n_{IJV}x_{IV} + (1-\theta)n_d x_d) + \frac{\theta I}{\beta_u^T} \end{array}\right] \\
= &\underbrace{\frac{\alpha(A_1 + n_{IJV}\beta_{IJV}x_{IJV})}{\beta_{IJV}}}_{<0} + \frac{\theta\left[\alpha^2\left(A_1 + A_2\right)P_U + I\left(\alpha P_U + (1-\alpha)w\right)\right]}{\beta_u^T\left(\alpha P_U + (1-\alpha)w\right)} \\
&\underbrace{+(1-\theta)\frac{\alpha\left(A_2 + n_d\beta_d^S x_d\right)}{\beta_d^S}}_{<0}
\end{aligned}$$

where the sign of the first and last term follow from the fact that $A_1, A_2 < 0$.[34] The sign of the second term is ambiguous however. We can derive a condition under which this term (and hence the entire Term 2) is negative, which obviously is the case if the numerator is negative:

$$\begin{aligned}
&\left[\alpha^2\left(A_1 + A_2\right)P_U + I\left(\alpha P_U + (1-\alpha)w\right)\right] \\
= \ &\alpha\left\{\begin{array}{c} (n_{IJV}\beta_{IJV}x_{IJV} + n_d\beta_d^S x_d)\left[\alpha(1-\eta)P_U + (1-\alpha)w\right] \\ +(\alpha P_U + (1-\alpha)w)(n_{IJV}F_{IJV} + n_d F_d^S) \end{array}\right\} < 0
\end{aligned}$$

For this condition to hold it is necessary to have:

$$\frac{(n_{IJV}\beta_{IJV}x_{IJV} + n_d\beta_d^S x_d)}{(n_{IJV}F_{IJV} + n_d F_d^S)} < -\frac{\alpha(1-\eta)P_U + (1-\alpha)w}{\alpha P_U + (1-\alpha)w}$$

$d\Pi_u/d\rho$ **if** $\theta = 1$

If $\theta = 1$, Term 1 reduces to $-w(F_m - F_n) > 0$. Hence, a sufficient condition for $d\Pi_u/d\rho > 0$ then is:

$$\frac{(n_{IJV}\beta_{IJV}x_{IJV} + n_d\beta_d^S x_d)}{(n_{IJV}F_{IJV} + n_d F_d^S)} < -\frac{\alpha(1-\eta)P_U + (1-\alpha)w}{\alpha P_U + (1-\alpha)w}$$

[34] Note that the condition in this case changes to $(\varepsilon - \eta)/(\varepsilon - 1) < 1$ which still holds since $\varepsilon > \eta > 1$.

$d\Pi_u/d\rho$ if $\theta = 0$

If $\theta = 0$, Term 1 is unambiguously positive and Term 2 unambiguously negative.

$$\frac{d\Pi_u}{d\rho} = \frac{\alpha w \beta_u^T x_u}{\sigma - 1}\left\{ \begin{array}{c} \underbrace{\frac{(n_{IJV} + n_d)}{I}(F_m - F_n)}_{<0} \\ +\underbrace{\left[\frac{A_1 + n_{IJV}\beta_{IJV}x_{IJV}}{\beta_{IJV}} + \frac{A_2 + n_d\beta_d^S x_d}{\beta_d^S}\right](\beta_m - \beta_n)}_{>0} \end{array} \right\}$$

There is no concise sufficient or necessary condition which ensures $d\Pi_u/d\rho$ is either positive or negative in this case.

B2 IJVs in the downstream sector - $d\Pi_d/d\rho$

The elements of $d\Pi_d/d\rho$ are:

$$\begin{aligned} PE_2 \equiv{}& \frac{\beta_d^S(\alpha P_U + (1-\alpha)w)}{(\varepsilon - 1)}\frac{\partial x_d}{\partial P_D} \\ & \left[\begin{array}{c} \frac{\partial P_D}{\partial p_d}\left[\frac{\partial p_d}{\partial \beta_d^S}\left[(1-\theta)(\beta_m - \beta_d)\right] + \frac{\partial p_d}{\partial P_U}\left[\frac{\partial P_U}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^T}\theta(\beta_m - \beta_d)\right]\right] \\ +\frac{\partial P_D}{\partial p_{IJV}}\left[\frac{\partial p_{IJV}}{\partial \beta_{IJV}}(\beta_m - \beta_d) + \frac{\partial p_{IJV}}{\partial P_U}\left[\frac{\partial P_U}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^T}\theta(\beta_m - \beta_d)\right]\right] \end{array} \right] \end{aligned}$$

$$KS_1 \equiv -(\alpha P_u + (1-\alpha)w)(1-\theta)\left[(F_m - F_d) + x_d(\beta_m - \beta_n)\right]$$

$$IDL_1 \equiv -\alpha(F_d^S + \beta_d^S x_d)\frac{\partial P_U}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^T}\theta(\beta_m - \beta_d)$$

Using the explicit expressions for the partial derivatives and collecting terms yields the following expression for $d\Pi_d/d\rho$:

$$\begin{aligned} \frac{d\Pi_d}{d\rho} ={}& (\varepsilon - \eta)\frac{p_d}{\varepsilon}x_d P_D^{\varepsilon-1}\left[p_d^{-\varepsilon}n_d A_3 + p_{IJV}^{-\varepsilon}n_{IJV}A_4\right](\beta_m - \beta_n) \\ & -(\alpha P_U + (1-\alpha)w)(1-\theta)\left[(F_m - F_d) + x_d(\beta_m - \beta_n)\right] \\ & -\alpha(F_d^S + \beta_d^S x_d)\frac{P_U}{\beta_u^T}\theta(\beta_m - \beta_n) \end{aligned}$$

with

$$A_3 \equiv \frac{p_d}{\beta_d^S}(1-\theta) + \alpha\beta_d^S\theta\frac{\varepsilon}{\varepsilon - 1}\frac{P_U}{\beta_u^T}$$

$$A_4 \equiv \frac{p_{IJV}}{\beta_{IJV}}(1-\theta) + \alpha\beta_d^S\theta\frac{\varepsilon}{\varepsilon-1}\frac{P_U}{\beta_u^T}$$

Signing this derivative is not straightforward. Therefore, we consider its sign under $\theta = 1$ and $\theta = 0$.

$d\Pi_u/d\rho$ **if** $\theta = 1$

If $\theta = 1$, $d\Pi_d/d\rho$ reduces to:

$$\begin{aligned} \frac{d\Pi_d}{d\rho} &= \alpha\frac{P_U}{\beta_u^T}(\beta_m - \beta_n)\left[p_d x_d P_D^{\varepsilon-1}\beta_d^S\frac{(\varepsilon-\eta)}{\varepsilon-1}\left[p_d^{-\varepsilon}n_d + p_{IJV}^{-\varepsilon}n_{IJV}\right] - (F_d^S + \beta_d^S x_d)\right] \\ &= \alpha\frac{P_U}{\beta_u^T}(\beta_m - \beta_n)\left[\beta_d^S x_d\left\{p_d P_D^{\varepsilon-1}\frac{(\varepsilon-\eta)}{\varepsilon-1}\left[p_d^{-\varepsilon}n_d + p_{IJV}^{-\varepsilon}n_{IJV}\right] - 1\right\} - F_d^S\right] \end{aligned}$$

Note that a sufficient condition for $d\Pi_d/d\rho$ to be positive is thus:

$$\begin{aligned} p_d P_D^{\varepsilon-1}\frac{(\varepsilon-\eta)}{\varepsilon-1}\left[p_d^{-\varepsilon}n_d + p_{IJV}^{-\varepsilon}n_{IJV}\right] &< 1 \\ \frac{\varepsilon-\eta}{\varepsilon-1} &< \frac{P_D^{1-\varepsilon}}{p_d\left[p_d^{-\varepsilon}n_d + p_{IJV}^{-\varepsilon}n_{IJV}\right]} \\ \frac{\varepsilon-\eta}{\varepsilon-1} &< \frac{\left[p_d^{1-\varepsilon}n_d + p_{IJV}^{1-\varepsilon}n_{IJV}\right]}{\left[p_d^{1-\varepsilon}n_d + p_d p_{IJV}^{-\varepsilon}n_{IJV}\right]} \end{aligned}$$

Given that $\varepsilon > \eta > 1$ the LHS of this condition < 1. Hence, if the RHS ≥ 1 the condition is always met. It can be shown that RHS ≥ 1 by noting that we in this case we need that $p_d \geq p_{IJV}$:

$$\begin{aligned} p_d &\geq p_{IJV} \\ &\Longleftrightarrow \frac{\varepsilon\beta_d^S(\alpha P_U + (1-\alpha)w)}{(\varepsilon-1)} \geq \frac{\varepsilon\beta_{IJV}(\alpha P_U + (1-\alpha)w)}{(\varepsilon-1)} \\ &\Longleftrightarrow \beta_d^S \geq \beta_{IJV} \\ &\Longleftrightarrow \theta\beta_d + (1-\theta)\beta_{IJV} \geq \beta_{IJV} \\ &\Longleftrightarrow \beta_d \equiv \beta_n \geq \beta_{IJV} \text{ (since } \theta = 1) \\ &\Longleftrightarrow \beta_n \geq \rho\beta_m + (1-\rho)\beta_n \end{aligned}$$

Since we have assumed that $\beta_m < \beta_n$ this condition is always met for for all $\rho \in [0,1]$.

$d\Pi_u/d\rho$ **if** $\theta = 0$

If $\theta = 0$, $d\Pi_d/d\rho$ reduces to:

$$\begin{aligned}
\frac{d\Pi_d}{d\rho} &= (\varepsilon-\eta)\frac{p_d}{\varepsilon}x_d P_D^{\varepsilon-1}\left[\frac{n_d p_d^{1-\varepsilon}}{\beta_d^S}+\frac{n_{IJV}p_{IJV}^{1-\varepsilon}}{\beta_{IJV}}\right](\beta_m-\beta_n) \\
&\quad -(\alpha P_U+(1-\alpha)w)\left[(F_m-F_d)+x_d(\beta_m-\beta_n)\right] \\
&= \left\{(\varepsilon-\eta)\frac{p_d}{\varepsilon}P_D^{\varepsilon-1}\left[\frac{n_d p_d^{1-\varepsilon}}{\beta_d^S}+\frac{n_{IJV}p_{IJV}^{1-\varepsilon}}{\beta_{IJV}}\right]-(\alpha P_U+(1-\alpha)w)\right\}\times \\
&\quad x_d(\beta_m-\beta_n)-(\alpha P_U+(1-\alpha)w)(F_m-F_d) \\
&= \left\{(\varepsilon-\eta)\frac{p_d}{\varepsilon}P_D^{\varepsilon-1}\left[\frac{n_d p_d^{1-\varepsilon}}{\beta_d^S}+\frac{n_{IJV}p_{IJV}^{1-\varepsilon}}{\beta_{IJV}}\right]-(\varepsilon-1)\frac{p_d}{\varepsilon\beta_d^S}\right\}x_d(\beta_m-\beta_n) \\
&\quad -(\alpha P_U+(1-\alpha)w)(F_m-F_d)
\end{aligned}$$

Note that a sufficient condition for $d\Pi_d/d\rho > 0$ is:

$$\frac{(\varepsilon-\eta)}{(\varepsilon-1)}\left[\frac{n_d p_d^{1-\varepsilon}}{\beta_d^S}+\frac{n_{IJV}p_{IJV}^{1-\varepsilon}}{\beta_{IJV}}\right] < \frac{P_D^{1-\varepsilon}}{\beta_d^S}$$

If $\beta_d^S = \beta_{IJV}$ this condition reduces to:

$$\begin{aligned}
\frac{(\varepsilon-\eta)}{(\varepsilon-1)}\left[\frac{n_d p_d^{1-\varepsilon}+n_{IJV}p_{IJV}^{1-\varepsilon}}{\beta_d^S}\right] &< \frac{P_D^{1-\varepsilon}}{\beta_d^S} \\
\frac{(\varepsilon-\eta)}{(\varepsilon-1)}\left[\frac{P_D^{1-\varepsilon}}{\beta_d^S}\right] &< \frac{P_D^{1-\varepsilon}}{\beta_d^S} \\
\frac{(\varepsilon-\eta)}{(\varepsilon-1)} &< 1
\end{aligned}$$

which as we saw above is always the case. Given that $\beta_d^S = \theta\beta_d + (1-\theta)\beta_{IJV}$ and the fact that $\theta = 0$, we indeed have that $\beta_d^S = \beta_{IJV}$ so that this condition always holds.

B3 IJVs in upstream sector - $d\Pi_u/d\rho$

First consider the elements of $d\Pi_u/d\rho$:

$$IDL_2 = \theta\frac{w\beta_u^S}{(\sigma-1)}\frac{\partial x_u}{\partial I}\left(\frac{\partial I}{\partial F_d^T}(F_m-F_d)+\frac{\partial I}{\partial \beta_d^T}(\beta_m-\beta_d)\right)$$

$$PE_3 = \frac{w\beta_u^S}{(\sigma-1)}\frac{\partial x_u}{\partial P_U}(\beta_m - \beta_d)\left(\frac{\partial P_U}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^S}(1-\theta) + \frac{\partial P_U}{\partial p_{IJV}}\frac{\partial p_{IJV}}{\partial \beta_{IJV}}\right)$$

$$KS_2 = -w(1-\theta)\left[(F_m - F_d) + x_u(\beta_m - \beta_n)\right]$$

Using the explicit expressions for the partial derivatives and collecting terms yields the following expression for $d\Pi_u/d\rho$:

$$\begin{aligned}\frac{d\Pi_u}{d\rho} &= \theta\mu n_d\frac{p_u}{\sigma}\frac{x_u}{I}\left[(F_m - F_n) + x_d(\beta_m - \beta_n)\right] \\ &\quad + x_u p_u P_U^{\sigma-1}(\beta_m - \beta_n)\frac{\sigma w}{\sigma-1}\left(n_u p_u^{-\sigma} + n_{IJV}p_{IJV}^{-\sigma}\right) \\ &\quad - w(1-\theta)\left[(F_m - F_d) + x_u(\beta_m - \beta_n)\right]\end{aligned}$$

The elements of $d\Pi_d/d\rho$ are:

$$PE_4 = \frac{p_d}{\varepsilon}\frac{\partial x_d}{\partial P_D}\frac{\partial P_D}{\partial p_d}(\beta_m - \beta_n)\left[\begin{array}{c}\frac{\partial p_d}{\partial \beta_d^T}\theta \\ +\frac{\partial p_d}{\partial P_U}\left(\frac{\partial P_U}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^S}(1-\theta) + \frac{\partial P_U}{\partial p_{IJV}}\frac{\partial p_{IJV}}{\partial \beta_{IJV}}\right)\end{array}\right]$$

$$KT_2 = -\theta(\mu P_U + (1-\mu)w)\left[(F_m - F_d) + x_d(\beta_m - \beta_n)\right]$$

$$FL_1 = -\mu\left(\beta_d^T x_d + F_d^T\right)\left((1-\theta)\frac{\partial P_U}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^S} + \frac{\partial P_U}{\partial p_{IJV}}\frac{\partial p_{IJV}}{\partial \beta_{IJV}}\right)(\beta_m - \beta_n)$$

Using the explicit expressions for the partial derivatives and collecting terms yields the following expression for $d\Pi_d/d\rho$:

$$\begin{aligned}\frac{d\Pi_d}{d\rho} &= \frac{x_d}{\varepsilon}(\beta_m - \beta_n)\left[\begin{array}{c}\theta\frac{p_d}{\beta_d^T} \\ +P_U^{\sigma}\frac{\varepsilon\mu\beta_d^T}{(\varepsilon-1)}\frac{\sigma w}{\sigma-1}((1-\theta)n_u p_u^{-\sigma} + n_{IJV}p_{IJV}^{-\sigma})\end{array}\right] \\ &\quad -\theta(\mu P_U + (1-\mu)w)\left[(F_m - F_d) + x_d(\beta_m - \beta_n)\right] \\ &\quad -\mu\left(\beta_d^T x_d + F_d^T\right)(\beta_m - \beta_n)P_U^{\sigma}\frac{\sigma w}{\sigma-1}((1-\theta)n_u p_u^{-\sigma} + n_{IJV}p_{IJV}^{-\sigma})\end{aligned}$$

It is clear that the firs two lines of this expression are positive, while the third line is negative.

$d\Pi_u/d\rho$ if $\theta = 1$

If $\theta = 1$ $d\Pi_u/d\rho$ reduces to:

$$\begin{aligned}\frac{d\Pi_u}{d\rho} &= \mu n_d \frac{p_u}{\sigma}\frac{x_u}{I}\left[(F_m - F_n) + x_d(\beta_m - \beta_n)\right] \\ &\quad + x_u p_u P_U^{\sigma-1}(\beta_m - \beta_n)\frac{\sigma w}{\sigma - 1}\left(n_u p_u^{-\sigma} + n_{IJV} p_{IJV}^{-\sigma}\right)\end{aligned}$$

which is clearly negative. Hence if $\theta = 1$, $d\Pi_u/d\rho < 0$.

$d\Pi_u/d\rho$ if $\theta = 0$

If $\theta = 0$ $d\Pi_u/d\rho$ reduces to:

$$\begin{aligned}\frac{d\Pi_u}{d\rho} &= x_u p_u P_U^{\sigma-1}(\beta_m - \beta_n)\frac{\sigma w}{\sigma - 1}\left(n_u p_u^{-\sigma} + n_{IJV} p_{IJV}^{-\sigma}\right) \\ &\quad - w\left[(F_m - F_d) + x_u(\beta_m - \beta_n)\right]\end{aligned}$$

Hence, a sufficient and necessary condition to have that $d\Pi_u/d\rho > 0$ in this case is that:

$$\begin{aligned} p_u P_U^{\sigma-1}\frac{\sigma}{\sigma - 1}\left(n_u p_u^{-\sigma} + n_{IJV} p_{IJV}^{-\sigma}\right) &< \frac{\left[(F_m - F_d) + x_u(\beta_m - \beta_n)\right]}{x_u(\beta_m - \beta_n)} \\ \frac{\sigma}{\sigma - 1}\frac{\left(n_u p_u^{1-\sigma} + n_{IJV} p_u p_{IJV}^{-\sigma}\right)}{\left(n_u p_u^{1-\sigma} + n_{IJV} p_{IJV}^{1-\sigma}\right)} &< \frac{\left[(F_m - F_d) + x_u(\beta_m - \beta_n)\right]}{x_u(\beta_m - \beta_n)}\end{aligned}$$

Given that $\theta = 0$ we have that $\beta_{IJV} = \beta_u^S$ and hence that $p_u = p_{IJV}$ i.e:

$$\frac{\sigma}{\sigma - 1} < \frac{\left[(F_m - F_d) + x_u(\beta_m - \beta_n)\right]}{x_u(\beta_m - \beta_n)}$$

Hence, the larger fixed costs relative to marginal costs (or more precisely: The more important the effect of knowledge diffusion on fixed rather than marginal costs), the more likely this condition is to hold, and hence, the more likely it is that $d\Pi_u/d\rho > 0$.

B4 IJVs in the upstream sector - $d\Pi_d/d\rho$

The elements of $d\Pi_d/d\rho$ are:

$$\begin{aligned} PE_4 \;=\; & \frac{\varepsilon\beta_d^T(\mu P_U+(1-\mu)w)}{(\varepsilon-1)}\frac{\partial x_d}{\partial P_D}\frac{\partial P_D}{\partial p_d}\times \\ & \left[\begin{array}{c} \frac{\partial p_d}{\partial \beta_d^T}\theta(\beta_m-\beta_n) \\ +\frac{\partial p_d}{\partial P_U}\left(\frac{\partial P_U}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^S}(1-\theta)+\frac{\partial P_U}{\partial p_{IJV}}\frac{\partial p_{IJV}}{\partial \beta_{IJV}}\right)(\beta_m-\beta_n) \end{array}\right] \end{aligned}$$

$$KT_2=-\theta(\mu P_U+(1-\mu)w)\left[(F_m-F_d)+x_d(\beta_m-\beta_n)\right]$$

$$FL_1=-\mu\left(\beta_d^T x_d+F_d^T\right)\left((1-\theta)\frac{\partial P_U}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^S}+\frac{\partial P_U}{\partial p_{IJV}}\frac{\partial p_{IJV}}{\partial \beta_{IJV}}\right)(\beta_m-\beta_u)$$

Using the explicit expressions for the partial derivatives and collecting terms yields the following expression for $d\Pi_d/d\rho$:

$$\begin{aligned} \frac{d\Pi_d}{d\rho} \;=\; & \frac{x_d}{\varepsilon}(\beta_m-\beta_n)\left[\begin{array}{c} \theta\frac{p_d}{\beta_d^T} \\ +P_U^{\sigma}\frac{\varepsilon\mu\beta_d^T}{(\varepsilon-1)}\frac{\sigma w}{\sigma-1}((1-\theta)n_u p_u^{-\sigma}+n_{IJV}p_{IJV}^{-\sigma}) \end{array}\right] \\ & -\theta(\mu P_U+(1-\mu)w)\left[(F_m-F_d)+x_d(\beta_m-\beta_n)\right] \\ & -\mu\left(\beta_d^T x_d+F_d^T\right)(\beta_m-\beta_n)P_U^{\sigma}\frac{\sigma w}{\sigma-1}((1-\theta)n_u p_u^{-\sigma}+n_{IJV}p_{IJV}^{-\sigma}) \end{aligned}$$

Clearly, the term in the first line is negative whereas the terms in the second and third lines are positive. From the analyses below it follows that $\varepsilon>2$ is a sufficient condition for $d\Pi_u/d\rho$ to be positive.

$d\Pi_u/d\rho$ **if** $\theta = 1$

If $\theta = 1$ $d\Pi_d/d\rho$ reduces to:

$$\begin{aligned}
\frac{d\Pi_d}{d\rho} &= \frac{x_d p_d}{\varepsilon}(\beta_m - \beta_n)\left[\begin{array}{c} \frac{p_d}{\beta_d^T} \\ +P_U^\sigma \frac{\varepsilon\mu\beta_d^T}{(\varepsilon-1)}\frac{\sigma w}{\sigma-1}(n_u p_u^{-\sigma} + n_{IJV} p_{IJV}^{-\sigma}) \end{array}\right] \\
&\quad -(\mu P_U + (1-\mu)w)\left[(F_m - F_d) + x_d(\beta_m - \beta_n)\right] \\
&\quad -\mu\left(\beta_d^T x_d + F_d^T\right)(\beta_m - \beta_n)P_U^\sigma \frac{\sigma w}{\sigma - 1}(n_u p_u^{-\sigma} + n_{IJV} p_{IJV}^{-\sigma}) \\
&= \frac{x_d}{\varepsilon}(\beta_m - \beta_n)\left[\frac{p_d}{\beta_d^T} - \varepsilon(\mu P_U + (1-\mu)w)\right] \\
&\quad +\mu P_U^\sigma \frac{\sigma w}{\sigma - 1}(n_u p_u^{-\sigma} + n_{IJV} p_{IJV}^{-\sigma})(\beta_m - \beta_n)\cdot \\
&\quad \left[\frac{x_d\beta_d^T}{(\varepsilon - 1)} - \left(\beta_d^T x_d + F_d^T\right)\right] \\
&\quad -(\mu P_U + (1-\mu)w)(F_m - F_d) \\
&= \frac{x_d}{\varepsilon}(\beta_m - \beta_n)\left[\frac{p_d(2-\varepsilon)}{\beta_d^T}\right] \\
&\quad +\mu P_U^\sigma \frac{\sigma w}{\sigma - 1}(n_u p_u^{-\sigma} + n_{IJV} p_{IJV}^{-\sigma})(\beta_m - \beta_n)\cdot \\
&\quad \left[\frac{x_d\beta_d^T(2-\varepsilon)}{(\varepsilon - 1)} - F_d^T\right]
\end{aligned}$$

Hence, a sufficient condition for $d\Pi_d/d\rho > 0$ when $\theta = 1$ is $\varepsilon > 2$.

$d\Pi_u/d\rho$ **if** $\theta = 0$

If $\theta = 0$ $d\Pi_d/d\rho$ reduces to:

$$\begin{aligned}
&\frac{d\Pi_d}{d\rho} = \mu P_U^\sigma \frac{\sigma w}{\sigma - 1}(n_u p_u^{-\sigma} + n_{IJV} p_{IJV}^{-\sigma})(\beta_m - \beta_n)\cdot \\
&\left[\frac{x_d\beta_d^T(2-\varepsilon)}{(\varepsilon - 1)} - F_d^T\right]
\end{aligned}$$

Hence, a sufficient condition for $d\Pi_d/d\rho > 0$ when $\theta = 0$ is $\varepsilon > 2$.

Table A1: Sample countries and industries

Countries	**Industries**
Australia	Mining of coal
Austria	Mining of metal ores
Belgium	Food products and beverages
Canada	Textiles
Denmark	Wood and wood products
Finland	Paper and paper products
France	Coke, petroleum and fuel
Germany	Chemicals and chemical products
Hong Kong	Rubber and plastic products
Israel	Other non-metallic and mineral products
Italy	Basic metals
Japan	Fabricated metal products
South Korea	Machinery and equipment
Netherlands	Electrical machinery and apparatus
Singapore	Medical, precision and optical instruments
Spain	Motor vehicles
Sweden	Furniture
Switzerland	Construction
United Kingdom	
United States	

Chapter 4

Market orientation and knowledge diffusion from FDI

4.1 Introduction

In the previous chapter is was established that the extent of MNE ownership over its foreign subsidiaries matters a great deal for the extent of intra and inter-industry knowledge diffusion. From the IJV profit function in (3.5) it follows that we have assumed throughout the chapter that the MNE's subsidiary locates production abroad to serve the foreign market. That is, we have assumed that the FDI involved in this process was of the local market-seeking type. However, as mentioned in Chapter 2 (Section 2.5.3) the literature on horizontal and vertical FDI suggests the market orientation of MNEs' subsidiaries might differ, and that such differences by themselves may be another relevant dimension of MNE heterogeneity, influencing host-country productivity effects.

Horizontal FDI occurs when a MNE copies (parts of) its value chain in a foreign subsidiary in order to serve the local market (*cf.* Markusen, 1984; Markusen, 2001). As such, it has also been called market-seeking FDI. Vertical FDI on the other hand occurs when a MNE slices up the value chain and relocates different activities to those places where they can be undertaken most efficiently (*cf.* Helpman, 1984; Markusen, 2001). Accordingly, this term has also been coined efficiency-seeking FDI (for an overview of the

[34] Parts of this chapter are based on Beugelsdijk, Smeets and Zwinkels (2008) and Smeets and Wei (2009).

different types of FDI, see Section 2.5.3). Recent literature on endogenous growth (Romer, 1991; Martin and Ottaviano, 1999; Baldwin, Braconier and Forslid, 2005) suggests that these two different types of FDI may have differing productivity effects as they have a different impact on industry learning curves.

In this chapter we will consider the host-country productivity effects of horizontal and vertical FDI. Although the models that have been developed to analyze these two FDI types are similar to the one we have used in Chapter 3, a key difference is that they include international trade, since MNE subsidiaries have to ship (intermediate) products back to their home country in case of vertical FDI. Hence, even though some of the model specifications and implications derived in the previous chapter still apply, we have to use a somewhat different model setup.

Specifically, we will utilize the model setup by Ekholm and Forslid (2001) in adapting an industry learning curve suggested by Martin and Ottaviano (1999) and accordingly derive the different productivity effects of the two FDI types. Using industry-level data on the foreign activities of US MNEs, we will then empirically test whether the implied differences indeed are borne out by the data. Following this, we will also consider the moderating effect of Regional Integration Agreements (RIAs) on the productivity effects of the two different FDI types, as both New Trade Theory (*cf.* Markusen, 2002) and the literature on RIAs (Dunning, 2000; Buckley, Clegg, Forsans and Reilly, 2003) suggest that the presence or absence of regional integration may have diverging effects on the composition and amount of both FDI types, and consequently on their host-country productivity effects.

The remainder of the chapter is structured as follows: Section 4.2 discusses the potentially different productivity effects of horizontal and vertical FDI, and the way in which RIAs impact on them through trade costs. Section 4.3 then discusses the data and variables that we employ to test the theoretical predictions, as well as the system GMM estimator that we use to do so. The empirical results are presented in Section 4.4. Finally, Section 4.5 discusses these results and concludes the chapter.

4.2 Theory

4.2.1 A model of horizontal and vertical FDI

In the literature on FDI, MNEs and international trade, a well-established distinction has been made between horizontal and vertical FDI (Markusen, 1984; Helpman, 1984; Markusen, 2001). Barba Navaretti and Venables (2004) define horizontal FDI as the duplication of a subset of a firm's activities in a foreign country, e.g. by setting up a foreign plant in addition to a home plant for some part of the production process. Hence, in this type of FDI, the same (horizontal) stage of the production process is duplicated. Vertical FDI on the other hand refers to breaking up the value-added chain, hence relocating separate (vertical) parts of this chain to those foreign locations where they are conducted most efficiently.

Other authors have used very similar definitions. According to Buckley and Casson (1981), horizontal FDI arises as a substitute for exporting and a desire to place production close to customers and thereby avoid trade costs, being both transportation costs and trade barriers. Vertical FDI is traditionally related to the desire of MNEs to carry out unskilled-labor intensive production activities in locations that are relatively abundant with unskilled labor (Braconier et al. 2005; Markusen, 1995). Following textbook international economics, vertical MNEs arise to take advantage of international factor-price differences and geographically split up their production process (Carr, Markusen and Maskus, 2001).

Ekholm and Forslid (2001) have formalized this distinction in a New Economic Geography model. The model setup is similar to the one developed in Chapter 3, although their analysis is conducted in general equilibrium. Moreover, in order to introduce geography, they consider two regions and iceberg transport costs for shipping goods between regions.[35]

Consider a two-country economy in which domestic firms (n), horizontal MNEs (h) and vertical MNEs (v) are active in an industry X. Production of X requires β units of labor (L) and one unit of variety-specific knowledge capital (K). K in turn is produced with α units of L in the innovation sector under perfect competition, so that it is priced at marginal costs.

Domestic firms produce in their home country and sell their products

[35] The name iceberg transport cost ($\tau \geq 1$) derives its name from the idea that part of the goods that are shipped melt away in transit. Hence, to deliver an amount x, somewhat more has to be shipped ($\tau \times x$).

both at home (in country j) and abroad (in country k) through exports. Exporting involves an iceberg transport cost, i.e. to sell x units abroad τx units have to be shipped ($\tau > 1$). This implies that profits for domestic firms are given by:

$$\Pi_n = p_j(x_{jj} + \tau x_{jk}) - [F + \beta(x_{jj} + \tau x_{jk})]\, w_j \tag{4.1}$$

where p_j is the price of good X in country j, $\tau p_j = p_k$ is the price of good X in country k, x_{jk} is the amount of good x produced in country j and sold in country k, w_j is the wage rate in country j, and $F = \alpha$ is the fixed cost for a unit of variety-specific knowledge capital.

Horizontal MNEs aim at serving both markets by establishing plants in both countries. In this way, these firms save on trade costs on the one hand, but forego plant-level economies of scale on the other hand (Brainard, 1997). Profits for horizontal MNEs are accordingly given by:

$$\Pi_h = p_j x_{jj} + p_k x_{kk} - \frac{(1+\gamma)F}{2}(w_j + w_k) - \beta(x_{jj}w_j + x_{kk}w_k) \tag{4.2}$$

where $\gamma > 0$ reflects the extent of the loss in plant-level economies of scale, or equivalently, the additional fixed costs of establishing a foreign subsidiary. This formulation is based on Ekholm and Forslid (2001), who argue that fixed costs should be shared equally across the two production plants in order to get rid of any vertical elements in the cost structure of the MNE.[36]

Vertical MNEs arise because of efficiency seeking or resource seeking motives. In Ekholm and Forslid (2001), the vertical MNE splits up production (associated with labor inputs L) from headquarter services (associated with capital inputs K which in turn are produced using $\alpha = F$ units of L). Labor costs for a vertical MNE with its production in country k and headquarters in country j in this case are given by:

$$\Pi_v = p_k(\tau x_{kj} + x_{kk}) - Fw_j - \beta(\tau x_{kj} + x_{kk})w_k \tag{4.3}$$

According to Barba Navaretti and Venables (2004) vertical FDI is not affected by loss of plant-level scale economies (since similar activities are still concentrated in one location), but instead by diseconomies of integration, in this case represented by the incurrence of transport costs τ.

[36] That is, since fixed costs are expressed in terms of labor, an asymmetric allocation of fixed costs in this case would imply that the MNE is exploiting lower wage costs in one of the countries, which reflects a vertical investment motive.

If all three firm types exist simultaneously in country j, the total knowledge capital stock is given by:[37]

$$K_j = n_j + (h_j + h_k)\frac{(1+\gamma)}{2} + v_j \tag{4.4}$$

The expression for the knowledge stock in country k is isomorphic. This knowledge stock is derived from the fact that all firms use one specific variety of knowledge capital in production, as well as the fact that a vertical MNE from country k has its headquarters – and thus its knowledge capital – in country k as well, thus not contributing to country j's knowledge capital stock.

The key to the different productivity effects of horizontal and vertical subsidiaries of MNEs lies exactly in this differing contribution to a country's knowledge stock. In the endogenous growth literature, knowledge spillovers have traditionally been modelled through so-called "learning curves" (Romer, 1990; Martin and Ottaviano, 1999; Baldwin et al., 2005). Such a learning curve specifies the evolution of (marginal) production costs in the innovation sector producing knowledge capital. Specifically, in the New Economic Geography literature, the following learning curve has been proposed by Martin and Ottaviano (1999):

$$F_j = \frac{1}{K_j + \lambda K_k} \text{ s.t. } 0 \leq \lambda < 1 \tag{4.5}$$

This equation states that the production costs of knowledge capital F in country j are inversely related to the total (i.e. world-wide) knowledge capital stock. That is, the larger the existing knowledge capital stock, the smaller are marginal production costs of an additional new variety of knowledge capital, which thus defines the knowledge diffusion effect. However, the extent to which the two different knowledge capital stocks contribute to this diffusion mechanism differs. Specifically, K_k contributes only λ as much to learning as K_j. As we saw already in Chapter 2, the reason for this is that knowledge diffusion has been found to be spatially bounded (Jaffe et al., 1993; Audretsch

[37] For all three firms to exist simultaneously, it is neccesary that their Ricardian surpluses are equivalent in equilibrium. The condition under which this is the case is derived in the Appendix to this chapter and given in (A2). This occurs when (i) trade costs and fixed investment costs hold each other in perfect balance, and (ii) wage differentials between the two countries are not too large, so that exporting from either country is equally profitable.

and Feldman, 1996; Keller, 2001). Hence, the knowledge capital stock in country k contributes less in terms of spillovers and transfers to country j than the knowledge stock of country j itself. As such, λ can be thought of as a localization parameter.

Now consider the effect of a change in the number of horizontal and vertical MNEs from country k on F_j in (4.5):

$$\frac{dF_j}{dh_k} = -\frac{(1+\gamma)(1+\lambda)}{2\left(K_j + \lambda K_k\right)^2} \tag{4.6}$$

$$\frac{dF_j}{dv_k} = -\frac{\lambda}{\left(K_j + \lambda K_k\right)^2} \tag{4.7}$$

Given the restrictions on γ and λ, it is immediately clear that the decrease in F_j due to an increase in h_k is larger than that due to an increase in v_k.[38] The intuition is also straightforward: The horizontal MNE employs knowledge capital in both countries, whereas the vertical MNE only in its headquarters in the foreign country. Moreover, only half of the horizontal MNE's knowledge stock diffusion effect is spatially bounded through λ, whereas this applies to the entire knowledge capital stock of the vertical MNE. Based on this observation, we expect horizontal FDI to generate larger knowledge diffusion effects than vertical FDI, as the effect on F_j will also increase n_j-firm profits in (4.1).

This theoretical derivation corresponds with studies that have found that knowledge transfer and knowledge spillovers from FDI are most likely if MNEs are well embedded in their host countries. Lall (1980) has identified a number of conditions under which spillovers for local firms are maximized. These all pertain to increasing the embeddedness of the MNE's affiliate in the local economy, like help setting up production facilities, involving local suppliers in the production process, and providing training to local suppliers (see also Chen et al. 2004). Investors who are only looking for cheap labour and are not interested in establishing local linkages typically operate in 'enclaves' (Singer, 1950), and as Kokko (1994) showed, spillovers are less likely in industries with 'enclave' characteristics where large technology gaps and high foreign shares coincide.[39]

[38] That is, $|dF_j/dh_k| > |dF_j/dv_k| \Leftrightarrow (1+\gamma)(1+\lambda) > 2\lambda$ which always holds since $0 \leq \lambda < 1$ and $\gamma > 0$.

[39] Note that this only holds since we have modelled the industry-learning curve as affecting fixed (knowledge capital) costs only (F), whereas in Chapter 3 we also modelled knowledge diffusion to occur through marginal costs (β).

The distinction between vertical and horizontal FDI and the spillover effect is also related to the MNE's global strategy, being - in extreme cases - either a strategy of global integration or local responsiveness (Prahalad and Doz, 1987; Bartlett and Ghoshal, 1989). Given the nature of vertical FDI as a critical input in the global production process, MNEs pursuing a strategy of global integration create relatively few linkages with local partners in order not to endanger the global production loop. Horizontal investments, associated with a relatively higher need for local partners, and associated with a strategy of local responsiveness, yield higher levels of local embeddedness and are associated with a relatively larger potential for spillovers compared with vertical FDI. In this context, Holm et al. (2003) have tested if the autonomy granted to a subsidiary affects the impact this FDI has on the local (Swedish) economy. They find that subsidiary impact on the host country economy is positively related to the autonomy granted to this subsidiary, supporting the view that those foreign affiliates that only serve as 'input' in the production process (vertical FDI) have a relatively low impact on their host economies. And those foreign affiliates still part of the global MNEs production process but with a clear separate role for themselves, positively affect the host environment.

4.2.2 Regional Integration Agreements

The model that was discussed in the previous section suggests that the amount and composition of FDI depends on transport or trade costs τ. Consequently, the existence of Regional Integration Agreements - usually set up to establish free trade among the member nations - can have important effects on FDI and the accompanying productivity effects. There is a relatively elaborate literature on the effects of Regional Economic Integration (REI) or Regional Integration Agreements (RIAs) on the amount and composition of trade and FDI flows (Dunning, 2000; Buckley et al., 2003). However, to the best of our knowledge, there is no study that analyzes the impact of RIAs on productivity effects of FDI.

Our sample of countries (*cf.* Table A.1 in the Appendix) allows us to distinguish between two RIAs: The Canada United States Free Trade Agreement (CUSFTA) and the European Union (EU). They differ in several notable respects: (1) CUSFTA only encompasses two countries, whereas the EU includes (during our sample period) 15 countries; (2) The home country (i.e. the US) is an insider in CUSFTA but an outsider to the EU; (3) CUSFTA allowed its members to pursue their individual third-country trade policies, notably tariffs, whereas the EU requires its members to harmonize their individual trade policies at the external border of the union; (4) The Internal Market Program in the EU ensures free movement of (production) factors - notably labor - between its member states, but this is not the case for CUSFTA. These aspects influence the amount and composition of US outward FDI into the member states of the two RIAs differently, and consequently different productivity effects may arise.

Regarding the extent of horizontal FDI, new trade theory suggests that RIAs will induce a substitution away from horizontal FDI and towards exports, since the RIA decreases the opportunity costs of exports by lowering trade costs (Markusen, 1984; 2002). This is also known as the proximity-concentration trade-off (Brainard, 1997). Its effect can be illustrated by making use of condition (A2) in the Appendix. For horizontal FDI, we focus on the first two terms of this condition (i.e. the terms on the LHS and RHS of the first = sign). To make the condition less unwieldy, assume symmetry across the two economies. Rearranging terms a bit, the condition becomes:

$$\gamma = \frac{1-\phi}{1+\phi} \tag{4.8}$$

where $\phi \equiv \tau^{1-\sigma} \in [0,1]$ is a freeness of trade parameter, and $\sigma > 1$ is the elasticity of substitution between two X sector varieties. ϕ takes a value of 0 when trade costs are prohibitive and 1 if trade is completely free. If condition (4.8) is satisfied, it is equally profitable to serve both markets either as a horizontal MNE or as a domestic firm. If $\gamma >$ RHS, the loss of scale economies when engaging in horizontal FDI is larger than the loss due to transport costs when exporting as a domestic firm. Hence, we would observe a substitution away from horizontal FDI and towards international (arm's length) trade when ϕ increases.[40]

As mentioned, two crucial differences between CUSFTA and the EU in this respect are that the US is an insider to CUSFTA but an outsider to the EU, and that the single market program in the EU only applies to member countries, but not at the external border. In other words, even though US firms benefit from CUSFTA in terms of decreased (or zero) trade costs, this

[40] To see the effect of a RIA on this condition, note that a RIA decreases trade costs τ, which implies an increase in ϕ. This in turn lowers the RHS of (4.8), so that *ceteris paribus* $\gamma >$ RHS. So indeed, we expect a RIA to induce a substitution away from horizontal FDI towards international trade.

does not apply (or less so) with respect to the EU. As such, we would expect the extent of horizontal FDI and the associated productivity effects to be larger in the EU than in CUSFTA.[41]

Models of vertical FDI (Helpman, 1984) predict an increase in this type of FDI as a consequence of RIA, since cross-border trade becomes cheaper. To see this, consider condition (A2) again, but now focus on the final two terms (i.e. the terms on the LHS and RHS of the second = sign). If these terms balance, it is equally profitable to serve both markets either as a vertical MNE or as a domestic firm. However, if the LHS is larger than the RHS, it is more profitable to do so through vertical FDI (with headquarters in j and production in k).[42] Hence, this induces a substitution away from arm's length international trade towards intra-firm international trade, i.e. vertical FDI.

To see how a RIA impacts on this mechanism, consider the effect of a reduction in trade costs (i.e. an increase in ϕ) on the RHS of this condition:

$$\frac{dRHS}{d\phi} = \frac{1}{1-\sigma}\left[\frac{(Y_k P_k^{\sigma-1})^2 - (Y_j P_j^{\sigma-1})^2}{D^2}\right]^{\frac{\sigma}{1-\sigma}} \tag{4.9}$$

where D is the denominator of the RHS of condition (A2). Since $\sigma > 1$, this condition is negative as long as real GDP in economy k (Y_j corrected by the price index) is larger than real GDP in economy j. The reason is that it is more profitable to produce and export from the larger economy as a vertical MNE with headquarters in country j and production in country k, than to do so from country j, given the presence of positive trade costs. Hence, a decrease in τ (i.e. an increase in ϕ) due to a RIA induces a substitution away from arm's length international trade and towards vertical FDI.

The crucial difference between CUSFTA and the EU in this context is again that the US is an insider to CUSFTA, but an outsider to the EU. This would imply that the extent of vertical FDI from the US will surely increase in CUSFTA, but not necessarily so in the EU. As such, we would expect the

[41] However, the EU could induce so-called export platform FDI by US MNEs (cf. Ekholm, Forslid and Markusen, 2007), in which US MNEs set up an export platform in one of the EU countries, and serve the others through exports from that platform. We will consider this possibility in the empirical analysis.

[42] Note that an increase in the LHS could imply *inter alia* that the wage in country j relative to the wage in country k has increased, making production in country k more attractive.

associated productivity effects of vertical FDI to be larger in CUSFTA than in the EU.

4.2.3 Other theoretical considerations

Next to the intra-industry knowledge diffusion effects analyzed above, the analysis in Chapter 3 also indicates that we should take into account price (and competition) effects, and inter-industry effects when analyzing net productivity effects. Regarding price effects, the formulation of the price index (A1) in the Appendix shows that the effects of vertical and horizontal MNEs from country k on price indices in country j are similar. Accordingly, in terms of competition effects, the entry of a horizontal MNE is also expected to have similar competition effects on domestic firms as the entry of a vertical MNE, since the horizontal MNEs can serve markets in country k at similar prices as vertical MNEs from k can. However, we note that our empirical analysis below is not conducted at the firm-level, but at the industry-level, so that we need to consider the effects of increased competition on industry productivity. In this case, it can be expected that the least productive (domestic) firms are the first that cannot meet zero-profit conditions anymore, and hence have to leave the market.[43] As such, the average industry-productivity is expected to increase due to increased competition effects, which further reinforces the superior productivity effect of horizontal over vertical FDI.

Finally, regarding the inter-industry effects, we have not considered these formally in the analysis above. However, the definitions of horizontal and vertical FDI given above suggest that horizontal FDI is more dependent on external local suppliers than vertical FDI, since the latter is part of a global MNE supply chain, and thus can depend on internal suppliers for intermediate goods. Accordingly, we thus expect backward productivity effects to be larger for horizontal than for vertical FDI. Similarly, forward productivity effects of horizontal FDI are also expected to outperform those of vertical FDI, since horizontal FDI is again more embedded in the local host-country economy in terms of local customers than vertical FDI. In fact, our proxies for vertical FDI (see below) imply that there are no forward productivity effects of vertical FDI at all.[44]

[43] Note that our model does not explicitly consider heterogeneity in productivity across firms (cf. Melitz, 2003 and Helpman et al., 2004).

[44] In this sense, the definition of vertical FDI (cf. Barba Navaretti and Venables, 2004) and our operation thereof diverges somewhat from the formalization based on Ekholm and

As far as the inter-industry effects in the two different RIAs are concerned, the literature on the influence of RIAs on sourcing patterns of MNEs argues that foreign affiliates will source more of their inputs internationally following a RIA, since importing inputs becomes cheaper (Tavares and Young, 2006). This implies that the extent of *local* (intranational) backward linkages and the related backward productivity effects will decrease following a RIA. As indicated in the previous subsection, due to its larger size and larger (economic) differences between its member states, the possibilities of international input sourcing are wider and more diverse in the EU (Cantwell, 1989), so that we expect the *local* backward productivity effects of all types of FDI to be larger in CUSFTA than in the EU. A similar argument could be applied regarding the forward productivity effects of horizontal FDI: Since the possibilities producing for a large and diverse international market unhampered by trade costs are larger in the EU than in CUSFTA, we would also expect that the accompanying local forward productivity effects in the EU are smaller than in CUSFTA.

In sum, based on the foregoing we expect both the intra-industry as well as the inter-industry productivity effects of horizontal FDI to be larger than those of vertical FDI. In addition, given the importance of transport costs for these different types of FDI, we also expect an impact of RIAs on the productivity effects of these two FDI types. Specifically, we expect that the effects of horizontal FDI are larger than those of vertical FDI in the EU, whereas the opposite holds in CUSFTA. In the rest of this chapter, we will investigate these issues empirically.

4.3 Data and methodology

4.3.1 Data

In constructing measures of horizontal and vertical FDI, we use industry-level data from the US Bureau of Economic Analysis (BEA). These data allow us to measure the activities of foreign affiliates of US MNEs in 13

Forslid (2001). According to the definition, vertical FDI only produces for and sells to other parts of the MNE so that no local sales in the host-country market occur. However, the formalization given above differs from this definition, as the vertical MNE still sells output in the host-country. This is a necessary assumption, since otherwise the decrease in vertical MNE profits would be too large for all three firms to be able to co-exist simultaneously (also see condition A2 the Appendix).

OECD countries over the period 1987-2003 (for a list of industries and host-countries used in this chapter, see Table A.1 in the Appendix). The BEA provides data regarding the operations of foreign subsidiaries on *inter alia* the amount of their annual sales, their net fixed capital stocks, the number of persons employed, and MNE R&D expenditures. The BEA data further allow us to distinguish the share of foreign affiliate sales of US MNEs destined for the local (host country) market. Accordingly, we proxy horizontal FDI as:

$$Horizontal\ FDI = \frac{local\ sales_{jkt}}{total\ sales_{jkt}} \times FDI_{jkt} \tag{4.10}$$

where j, k and t index industry, country and time respectively and FDI is a proxy of foreign MNE presence. Specifically, in reporting our results below, we use three different proxies for FDI: (1) Subsidiary capital stocks, (2) subsidiary employment, (3) subsidiary R&D stocks. Taking these three different measures of MNE presence follows up on an observation by Görg and Strobl (2001) that different measures yield different empirical results (*cf.* Section 2.2). Wei and Liu (2006) and Wei et al. (2008) argue that this may be due to the fact that different measures relate to different diffusion mechanisms. Applying a proxy of foreign capital (our first proxy), the positive spillover effect may simply indicate that the foreign presence produces a positive capital spillover effect. In this case, the positive externalities are closely related to the demonstration effect of the suitability of the project, or the superiority of machinery or equipment embodying updated technologies. Applying a proxy of employment in foreign firms (our second proxy), the spillover effect may be closely associated with employee turnover or contagion between employees in foreign and local firms. Finally, applying a proxy of R&D in foreign firms (our third proxy), the spillover effects are likely to be linked with knowledge diffusion of the superior product or knowledge acquisition via reverse engineering of the product.

As mentioned in footnote 44, empirical proxies for vertical FDI generally diverge from the formal approach outlined in the previous section, in the sense that they only capture that part of production which is exported back home (Barba- Navaretti and Venables, 2004; Braconier, Norbäck and Urban, 2005; Ekholm et al., 2007). Nonetheless, to proxy vertical FDI, we have several options. If we follow the model as strictly as possible, we should only consider the exports from the subsidiary back to the parent firm or home country as a valid proxy for vertical FDI. However, given that MNEs slice up their value-added chain in more than two pieces, it can reasonably be expected that subsidiaries will also export intermediates to each other, in which case we should also include other intra-firm (affiliate-affiliate) exports as a proxy for vertical FDI. Unfortunately, regarding intra-firm trade we only have data on parent-subsidiary trade, and not on subsidiary-subsidiary trade. Therefore, we employ several different computation methods. First, we compute:

$$Vertical\ FDI = \frac{exports\ to\ other\ countries_{jkt}}{total\ sales_{jkt}} \times FDI_{jkt} \tag{4.11}$$

Since these exports to some extent also capture exports from subsidiaries to unaffiliated parties (which does not belong to vertical FDI but instead can be coined as export platform FDI), we split up this variable and also consider the productivity effects of:

$$Parent\ Vertical\ FDI = \frac{exports\ to\ US\ parent_{jkt}}{total\ sales_{jkt}} \times FDI_{jkt} \tag{4.12}$$

$$Export\ FDI = \frac{exports\ to\ third\ countries_{jkt}}{total\ sales_{jkt}} \times FDI_{jkt} \tag{4.13}$$

In order to capture the inter-industry effects, we employ a similar strategy as in Chapter 3. Specifically, in order to capture the forward productivity effects of horizontal FDI, we compute:

$$\begin{aligned} Forward\ Horizontal\ FDI_{jt} &= \sum_j \left(\mu_{jh} \times Horizontal\ FDI_{ht}\right) \\ \text{s.t. } j &\neq h \end{aligned} \tag{4.14}$$

where μ_{jh} is the share of output supplied by industry h to industry j, not including intra-industry supplies. Note that given our different proxies of vertical FDI as defined above, by construction they do not generate any local forward productivity effects, since none of their output is destined for the local market and hence they are not related to any local downstream (customer) firms.

Backward productivity effects in turn are captured by:

$$\begin{aligned} Backward\ Horizontal\ FDI_{jt} &= \sum_j \left(\alpha_{jh} \times Horizontal\ FDI_{ht}\right) \\ \text{s.t. } j &\neq h \end{aligned} \tag{4.15}$$

where α_{jh} is the share of inputs purchased by industry h from industry j, again not including intra-industry supplies. Similar backward measures are also computed for $Vertical\ FDI$, $Home\ Vertical\ FDI$ and $Other\ Vertical\ FDI$. The input-output data were obtained from the OECD.[45]

4.3.2 Method

The model we wish to estimate resembles model (2.8) in Chapter 2 and takes the following form:

$$\omega_{jkt} = \beta_0 + \boldsymbol{\beta}_1 \mathbf{FDI}_{jk,t-1} + \boldsymbol{\beta}_2 \mathbf{X}_{jkt} + \eta_j + \nu_k + \upsilon_t + \varepsilon_{jkt} \tag{4.16}$$

where as before j, k and t index industry, country and time respectively, ω is total factor productivity (TFP), **FDI** is a vector with measures of horizontal and vertical FDI in period $t-1$ to take into account the lag between MNE activity and productivity change (i.e. it takes time for FDI to have its full impact on productivity), **X** is a vector of control variables, η, ν and υ are fixed effects and ε is an idiosyncratic error term. We use two control variables in the vector **X**: (the log of) industry-level exports, measured in millions of US dollars and also taken from the STAN database (*Exports*), and (the log of) industry-level R&D stocks, computed from data on R&D expenditures (from the OECD ANBERD database – *R&D*) using the perpetual inventory method and imposing a generic annual depreciation rate of 15% (Hall and Mairesse, 1995).[46] Since industry-level exports also contain the exports of the US MNEs in our sample that we use in constructing the different FDI types, we net out those exports from the industry aggregate.

As in Chapter 3, we first derive TFP as the residuals from production functions that we estimate for each industry separately. Specifically, log linearizing a Cobb-Douglas production function we estimate (with lower case letters denoting logs):

$$y_{jkt} = \gamma_0 + \gamma_{1j} l_{jkt} + \gamma_{2j} k_{jkt} + \omega_{jkt} \tag{4.17}$$

[45] A couple of comments apply here. First, the sector definitions and levels of aggregation of the OECD and BEA differ, we appropriately aggregated the OECD data before constructing valid I-O shares. Second, for most OECD countries, I-O data are only available for 1995-2002. We therefore used the 1995 data for the years 1987-1995, and the 2002 data for the years 1996-2003. We have used alternative assignments and the qualitative results remain.

[46] Logs of these variables are used since their distributions are rather skewed, with a few industry-country pairs demonstrating very high levels of R&D stocks and exports.

where y is value added, l are labor inputs and k are capital inputs. The data for y and k are obtained from the OECD STAN database, and the data on l from the Groningen Growth and Development Center (GGDC). y and k are measured in millions of US dollars, and the latter are computed from data on capital expenditures using the perpetual inventory method and imposing a generic annual depreciation rate of 5% (Hall and Mairesse, 1995). l is measured in (thousands) of hours worked. We estimate this production function with Generalized Least Squares (GLS).[47] All variables have been deflated using industry-level GDP deflators.[48] When appropriate, variables measured in foreign currencies (in case of OECD data) have been transformed into US dollars using 1995 PPP exchange rates.

We follow Girma and Görg (2007) and assume that (the log of) TFP follows and AR(1) process with fixed effects (already included in model (4.16)):

$$\omega_{jkt} = \rho\omega_{jk,t-1} + \eta_j + \nu_k + \upsilon_t + \varepsilon_{jkt} \tag{4.18}$$

so that combining this process with model (4.16) yields the following empirical model:

$$\omega_{jkt} = \beta_0 + \rho\omega_{jk,t-1} + \boldsymbol{\beta}_1\mathbf{FDI}_{jk,t-1} + \boldsymbol{\beta}_2\mathbf{X}_{jkt} + \eta_j + \nu_k + \upsilon_t + \varepsilon_{jkt} \tag{4.19}$$

This is the empirical model that will be estimated below.

As mentioned in Section 2.2, the potential endogeneity of FDI is a well-known problem: If foreign investors set up their subsidiaries in more productive countries, sectors or regions, any inferred productivity effects from FDI in model (4.19) will be spurious. Using lagged FDI variables could to some extent address this problem, however, this solution is less suited in situations where the series are persistent over time, which is the case here. Reverting to instrumental variable (IV) regression analysis would provide an alternative way out of this situation, but such an approach is not straightforward in the present context: even though the gravity literature provides a number of

[47] Note that in Chapter 3, we used the Olley and Pakes (1996) methodology to correct for the fact that the variable inputs will be correlated with TFP in model (4.17). However, as noted by Bitzer, Geishecker and Görg (2008), this is not neccesary when estimating production functions at the industry level, since it could then be argued that output or value added is stochastic, so that OLS or GLS leads to consistent coefficient estimates.

[48] Although Kafouros and Buckley (2008) argue and demonstrate that the use of common deflators is not appropriate when dealing with R&D expenditures, we are not aware of more specific deflators for these countries and sectors on the scale used in our sample. As such, we use GDP deflators for R&D as well.

potentially exogenous instruments for FDI (*cf.* Frankel and Romer, 1999), these mainly function at the country level rather than the industry level that we explore in this paper.

Additionally, the lagged dependent variable $\omega_{jk,t-1}$ captures dynamic adjustments of sectoral productivity. To the extent that productivity depends on its past realizations (e.g. due to learning effects or business cycles), its inclusion is important to control for "sluggish" adjustment of the productivity and to obtain unbiased coefficient estimates of the other explanatory variables (Baum, 2006). However, it again induces endogeneity since $\omega_{jk,t-1}$ is by definition correlated with the error term ε_{jkt}.

Under these circumstances, it is appropriate to revert to Generalized Method of Moments (GMM) estimation (Baum, 2006; Roodman, 2006). One specific estimator in this context is difference-GMM by Arrelano and Bond (1991) which transforms the model in (4.19) into first differences:

$$\Delta\omega_{jkt} = \rho\Delta\omega_{jk,t-1} + \boldsymbol{\beta}_1\Delta\mathbf{FDI}_{jk,t-1} + \boldsymbol{\beta}_2\Delta\mathbf{X}_{jkt} + \Delta\upsilon_t + \Delta\varepsilon_{jkt} \tag{4.20}$$

This removes the country and industry-level fixed effects, but it does not solve the endogeneity problem since $\omega_{jk,t-1}$ in $\Delta\omega_{jk,t-1}$ is now correlated with $\varepsilon_{jk,t-1}$ in $\Delta\varepsilon_{jkt}$. However, under the assumptions that the error term is not serially correlated and that explanatory variables are not correlated with future realizations of the error term, deeper lags of the explanatory variables are orthogonal to the error term, and hence may serve as proper instruments (*cf.* Carkovic and Levine, 2005). Thus the following moment conditions are used:

$$\begin{aligned} E(\omega_{jk,t-s} \cdot (\varepsilon_{jkt} - \varepsilon_{jk,t-1})) &= 0 \quad \text{s.t. } s \geq 2; t = 3,..,T \\ E(\mathbf{FDI}_{jk,t-s} \cdot (\varepsilon_{jkt} - \varepsilon_{jk,t-1})) &= 0 \quad \text{s.t. } s \geq 2; t = 3,..,T \end{aligned} \tag{4.21}$$

However, to the extent that these explanatory variables are persistent over time or close to a random walk, lagged levels contain little information about future changes, and as such they will make weak instruments (Carkovic and Levine, 2005; Roodman, 2006).

Blundell and Bond (1998) solve this problem by extending the outlined approach to also include the levels equation in model (4.19), and using lagged differences – i.e. $\Delta\omega_{jk,t-s}$ and $\Delta\mathbf{FDI}_{jk,t-s}$ – to instrument the endogenous variables ω and **FDI**. These instruments are uncorrelated with the country and industry-level fixed effects, i.e.:

$$\begin{aligned} E((\omega_{jk,t-s} - \omega_{jk,t-s-1}) \cdot (\eta_j + \nu_k + \varepsilon_{jkt})) &= 0 \quad \text{s.t. } s \geq 1 \quad (4.22) \\ E((\mathbf{FDI}_{jk,t-s} - \mathbf{FDI}_{jk,t-s-1}) \cdot (\eta_j + \nu_k + \varepsilon_{jkt})) &= 0 \quad \text{s.t. } s \geq 1 \end{aligned}$$

For estimation purposes, the Blundell-Bond estimator builds a system of both models in (4.19) and (4.20) but treats them as a single-equation. As such, this estimator is called the system-GMM estimator, and we adopt it here as it exploits more information in the data than the difference-GMM estimator alone.

Given the relatively limited amount of observations in our sample (N = 550 in the largest sample), we are forced to restrict the number of lags used in instrumentation to avoid over-fitting of the model (Roodman, 2006). Following Driffield and Love (2007), we first impose a maximum lag structure of 4 years. However, further inspection indicates that the error term in model (4.19) is autocorrelated up to AR(4), which renders the first four lags of the instruments for the endogenous variables invalid (since they are not exogenous). Hence, we use lags 5-8 to instrument the endogenous variables. Moreover, we employ the one-step estimator. As Madariaga and Poncet (2007) argue, although the two-step estimator is more efficient, it is only appropriate in relatively large samples, otherwise it heavily biases the coefficient estimates. Finally, we utilize the small sample correction proposed by Roodman (2006), include time dummies in order to minimize the occurrence of contemporaneous (cross-section) correlation, and report robust standard errors.[49]

Table 4.1 shows some summary statistics and pairwise correlations of the different variables. There is a relatively high correlation between R&D and exports (0.63). Even though we include both variables simultaneously in the empirical specifications below, running the regressions with either one of them did not change the results much. In addition, there is a relatively high degree of correlation between the backward variables of $Horizontal\ FDI$ on the one hand, and the backward variables of the vertical FDI types on the other, which has led us not to include them in the model simultaneously. Finally, the high correlation between the backward variables of $Vertical\ FDI$

[49] Although the definition of a "small sample" is somewhat arbitrary, the effect of this correction is that t-statistics instead of z-statistics are used to determine statistical significance, which seems appropriate given the maximum dimensions of our sample ($N = 13 \times 8$ and $T = 17$).

Table 4.1: Descriptive statistics and pairwise correlations (N=547)

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1. Log TFP	1.00												
2. Log lagged TFP	0.92	1.00											
3. Log R&D	0.19	0.19	1.00										
4. Log Exports	-0.06	-0.09	0.63	1.00									
5. Horizontal FDI	-0.17	-0.13	0.32	0.19	1.00								
6. Vertical FDI	0.19	0.14	0.20	0.11	-0.43	1.00							
7. Parent Vertical FDI	0.22	0.19	-0.08	-0.16	0.00	0.34	1.00						
8. Export FDI	0.07	0.03	0.25	0.20	-0.45	0.83	-0.25	1.00					
9. Backward Horizontal FDI	-0.03	-0.02	0.04	0.08	0.16	-0.22	0.01	-0.23	1.00				
10. Backward Vertical FDI	0.04	0.04	0.03	0.03	0.05	-0.20	0.01	-0.21	0.82	1.00			
11. Backward Parent Vertical FDI	0.10	0.11	0.12	-0.05	0.10	-0.10	0.33	-0.30	0.50	0.56	1.00		
12. Backward Export FDI	-0.02	-0.03	-0.03	0.06	0.00	-0.17	-0.19	-0.06	0.68	0.86	0.08	1.00	
13. Forward Horizontal FDI	-0.11	-0.12	-0.39	0.32	0.25	0.13	0.29	-0.04	0.33	0.14	0.16	0.06	1.00
Mean	0.13	0.10	8.20	9.35	3.59	2.77	0.55	2.22	0.40	0.26	0.07	0.20	0.93
standard deviation	0.35	0.35	1.52	1.23	1.75	1.56	0.90	1.52	0.53	0.39	0.19	0.34	0.71

Notes: Correlations $>|.08|$ are significant at $p<.05$.

and its two subtypes (*Parent Vertical FDI* and *Export FDI*) is not a problem since they never enter the model simultaneously either.

4.4 Empirical results

Table 4.2 presents the empirical results with *Horizontal FDI* and *Vertical FDI* as the variables of interest. Each group of three columns utilizes a different proxy for *FDI*: capital stocks (columns 1, 4 and 7), employment levels (columns 2, 5 and 8), and R&D stocks (columns 3, 6 and 9). Moreover, all the FDI coefficients reported in the tables below are standardized coefficients. The reason for reporting standardized coefficients is that we want to be able to meaningfully compare the marginal effects of *Horizontal FDI* and *Vertical FDI*. However, the summary statistics in Table 4.1 clearly indicate that both the mean and standard deviation between these two FDI types differ substantially, especially when splitting up *Vertical FDI*. As such, comparing regular coefficient estimates would be invalid, as differences in magnitude are partly a reflection of the different within-sample distributional properties of the different variables. In this case, comparing the standardized coefficients allows us to make meaningful inferences regarding the different marginal impact effects, as the within-sample distributions of the variables are equalized.

First consider the results of columns (1)-(3), where only the intra-industry effects of the different FDI types are considered. *Horizontal FDI* is positive and significant only when capital stocks are used as the FDI proxy, and insignificant in the other cases. *Vertical FDI* on the other hand is positive and significant for all FDI proxies. Moreover, when capital stocks are used, the marginal effect of *Vertical FDI* is larger than that of *Horizontal FDI*, a results which is not in accordance with the expectations that we formulated in Section 4.2.1. The other explanatory variables are all significant and with the expected sign. Finally, the bottom of the table provides the statistical tests of the models. The Sargan-Hansen test statistics of overidentifying restrictions are never significant, suggesting that the null hypothesis of valid (i.e. exogenous) instruments can be accepted. The AR statistics indicate first-order autocorrelation, as we would expect (given the inclusion of the lagged dependent variable), but no serial correlation from AR(5) onwards, confirming that our use of period 5-8 lagged instruments is valid (*cf.* Section 4.3.2).

Table 4.2: Productivity effects of horizontal and vertical FDI

	(1)Capital	(2)Labor	(3)R&D	(4)Capital	(5)Labor	(6)R&D	(7)Capital	(8)Labor	(9)R&D
(Log) lagged TFP	0.923***	0.942***	0.911***	0.931***	0.944***	0.901***	0.923***	0.933***	0.914***
	(.026)	(.029)	(.037)	(.020)	(.026)	(.031)	(.024)	(.027)	(.031)
(Log) R&D Stock	0.030***	0.030***	0.028**	0.029**	0.027***	0.025**	0.028***	0.030***	0.024*
	(.009)	(.009)	(.013)	(.008)	(.008)	(.011)	(.008)	(.009)	(.012)
(Log) Exports	0.021***	0.021**	0.020**	0.017**	0.016*	0.023**	0.015*	0.017*	0.009
	(.008)	(.009)	(.010)	(.007)	(.009)	(.009)	(.008)	(.009)	(.008)
Horizontal FDI^{a,b}	0.032**	0.008	0.009	0.040**	0.019	0.008	0.025	0.011	0.001
	(.015)	(.015)	(.010)	(.017)	(.014)	(.011)	(.017)	(.011)	(.010)
Vertical FDI^{a,b}	0.047***	0.032***	0.049**	0.057***	0.041***	0.052**	0.041***	0.031***	0.040**
	(.014)	(.011)	(.021)	(.012)	(.012)	(.021)	(.013)	(.010)	(.020)
Forward horizontal FDI^{a,b}				−0.032	−0.033	−0.054			
				(.024)	(.025)	(.034)			
Backward horizontal FDI^{a,b}				−0.002	0.008	0.012			
				(.010)	(.012)	(.012)			
Backward vertical FDI^{a,b}							−0.005	−0.007	−0.003
							(.007)	(.006)	(.007)

Table 4.2 (continued)

	(1)Capital	(2)Labor	(3)R&D	(4)Capital	(5)Labor	(6)R&D	(7)Capital	(8)Labor	(9)R&D
Constant	0.245^{**}	0.215^{**}	0.307^{**}	0.282^{***}	0.246^{**}	0.174^{*}	0.289^{***}	0.274^{***}	0.297^{***}
	(.101)	(.097)	(.064)	(.101)	(.097)	(.093)	(.104)	(.092)	(.108)
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-stat	125.9^{***}	102.36^{***}	137.8^{***}	160.6^{***}	105.9^{***}	150.6^{***}	157.8^{***}	110.0^{***}	198.6^{***}
AR(1)	-4.96^{***}	-5.02^{***}	-4.74^{***}	-4.90^{***}	-4.92^{***}	-4.74^{***}	-4.89^{***}	-4.89^{***}	-4.84^{***}
AR(5)	-1.01	-0.95	-1.59	-1.03	-1.01	-1.55	-1.28	-1.11	-1.48
Sargan-Hansen test	40.2	44.3	43.7	36.5	41.0	44.0	40.6	46.3	41.4
N	547	550	453	547	550	453	547	550	453

Notes: Dependent variable is (log) TFP; a) 1-period lagged values of the variables are used; b) Reported coefficients are standardized. System GMM-estimates - One step robust estimator, lags 5-8 used for endogenous variables. * $p<0.1$; ** $p<0.05$; ***$p<0.01$

Columns (4)-(6) report results including backward and forward effects from $Horizontal\ FDI$, whereas columns (7)-(9) include backward effects from $Vertical\ FDI$. The results are similar as before: in column (4) we again observe a positive and significant intra-industry effect of $Horizontal\ FDI$, whereas $Vertical\ FDI$ is positive and significant in all cases. Once again, the differences in coefficient sizes between $Horizontal/FDI$ and $Vertical\ FDI$ in column (4) are the opposite of what we would expect. Additionally, the positive effect of $Horizontal\ FDI$ has disappeared completely in column (7).

It seems that including the backward effects of $Vertical\ FDI$ influences the estimated intra-industry effects of $Horizontal\ FDI$, even though in none of the columns (7)-(9) the inter-industry effects are significant. As such, we generally have most confidence in the results of the first three columns, indicating that the effects of $Horizontal\ FDI$ are only positive and significant when capital stocks are used, whereas $Vertical\ FDI$ has a positive and significant effect for all FDI proxies.

A possible explanation for the unexpected result that the coefficient of $Horizontal\ FDI$ is smaller than that of $Vertical\ FDI$ could be related to the different components of $Vertical\ FDI$. As we discussed in Section 4.3.1, $Vertical\ FDI$ consists of exports back to parent companies ($Parent\ Vertical\ FDI$) and exports to third countries ($Export\ FDI$), which largely resembles export platform FDI. Since only $Parent\ Vertical\ FDI$ corresponds closely to the operationalization of vertical FDI in the model in Section 4.2.1, a true test of the model's implications should compare $Horizontal\ FDI$ with $Parent\ Vertical\ FDI$. To investigate this issue further, consider Table 4.3. It has a similar setup as Table 4.2, but now we further disentangle $Vertical\ FDI$ into $Parent\ Vertical\ FDI$ and $Export\ FDI$.

Similar to the results in Table 4.2, $Horizontal\ FDI$ has a consistently positive and significant effect only when capital stocks are used and the backward effects of $Parent\ Vertical\ FDI$ and $Export\ FDI$ are excluded. However, comparing its coefficient estimate with that of $Parent\ Vertical\ FDI$ in columns (1) and (4), it is clear that the effect of $Horizontal\ FDI$ is indeed larger, as expected. Additionally, we now also find a relatively consistent negative forward productivity effect of $Horizontal\ FDI$ in columns (4)-(6).

Next consider the effects of $Parent\ Vertical\ FDI$. We find consistently positive and significant effects of this type of FDI and its coefficient estimate is consistently smaller than that of $Horizontal\ FDI$ when capital stocks

Table 4.3: Productivity effects of horizontal and vertical FDI - Splitting up Vertical FDI

	(1)Capital	(2)Labor	(3)R&D	(4)Capital	(5)Labor	(6)R&D	(7)Capital	(8)Labor	(9)R&D
(Log) lagged TFP	0.929***	0.932***	0.906***	0.921***	0.925***	0.890***	0.940***	0.918***	0.900***
	(.028)	(.033)	(.038)	(.022)	(.029)	(.034)	(.019)	(.027)	(.029)
(Log) R&D Stock	0.031***	0.029***	0.028**	0.030***	0.019**	0.022**	0.020***	0.029***	0.027**
	(.009)	(.010)	(.013)	(.008)	(.008)	(.011)	(.007)	(.011)	(.012)
(Log) Exports	0.019**	0.019**	0.022**	0.017**	0.010	0.025***	0.007	0.015*	0.013
	(.009)	(.009)	(.009)	(.007)	(.009)	(.009)	(.010)	(.009)	(.008)
Horizontal FDI^{a,b}	0.034*	0.010	0.006	0.034*	0.006	0.002	0.014	0.004	0.001
	(.019)	(.016)	(.010)	(.020)	(.009)	(.010)	(.015)	(.014)	(.010)
Parent Vertical FDI^{a,b}	0.020***	0.015***	0.023***	0.032***	0.023***	0.033***	0.021***	0.014**	0.019***
	(.005)	(.005)	(.007)	(.005)	(.005)	(.010)	(.005)	(.006)	(.006)
Export FDI^{a,b}	0.042***	0.022*	0.039*	0.052***	0.029***	0.038**	0.023**	0.025**	0.035*
	(.016)	(.013)	(.020)	(.013)	(.011)	(.018)	(.012)	(.012)	(.018)

Table 4.3 (continued)

	(1)Capital	(2)Labor	(3)R&D	(4)Capital	(5)Labor	(6)R&D	(7)Capital	(8)Labor	(9)R&D
Forward Horizontal FDI^{a,b}				−0.041*	−0.038*	−0.067*			
				(.023)	(.023)	(.035)			
Backward Horizontal FDI^{a,b}				0.006	0.012	0.013			
				(.010)	(.011)	(.012)			
Backward Parent Vertical FDI^{a,b}							−0.010	0.004	0.019**
							(.006)	(.005)	(.009)
Backward Export FDI^{a,b}							−0.007	−0.006	−0.015**
							(.006)	(.006)	(.007)
Constant	0.279**	0.238**	0.195*	0.276**	0.245***	0.135	0.302***	0.293***	0.290***
	(.119)	(.108)	(.112)	(.118)	(.091)	(.093)	(.114)	(.092)	(.088)
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-stat	142.8***	99.6***	204.4***	238.9***	154.8***	192.3***	194.3***	183.1***	282.2***
AR(1)	−5.03***	−5.00***	−4.82***	−5.00***	−4.93***	−4.78***	−5.00***	−4.98***	−4.88***
AR(5)	−1.04	−0.92	−1.53	−1.03	−0.97	−1.48	−1.26	−1.29	−1.52
Sargan-Hansen test	42.1	41.4	43.0	38.0	42.1	41.5	38.8	38.7	37.4
N	547	550	453	547	550	453	547	550	453

Notes: Dependent variable is (log) TFP; a) 1-period lagged values of the variables are used; b) Reported coefficients are standardized. System GMM-estimates - One step robust estimator, lags 5-8 used for endogenous variables. * p<0.1; ** p<0.05; ***p<0.01

are used. Moreover, there are no consistent backward productivity effects of *Parent Vertical FDI*, even though they show up positively and significantly when R&D stocks are used to proxy FDI.

Finally, *Export FDI* is positive and significant in all cases, and its coefficient estimate is consistently larger than that of *Parent Vertical FDI* and *Horizontal FDI*. This seems to indicate that the unexpected results when comparing *Horizontal FDI* and *Vertical FDI* in Table 4.2 are mainly driven by the substantially larger effect of *Export FDI*. None of its inter-industry productivity effects are consistently significant, although again there is an indication of a negative backward effect when affiliate R&D stocks are used.

In sum, it appears that splitting up *Vertical FDI* into *Parent Vertical FDI* and *Export FDI* yields results that are more consistent with our theoretical expectations, since in that case the effect of *Horizontal FDI* is indeed larger than that of *Parent Vertical FDI*, at least when affiliate capital stocks are used. However, as discussed in Section 4.2.2, given the importance of trade costs for these different types of FDI, this may still not be the whole story. In particular, our theoretical model leads us to expect different results for the EU on the one hand and CUSFTA on the other.

Table 4.4 presents the results of the empirical analysis when accounting for these two regions. The setup is the same as before: Columns (1)-(3) only consider the intra-industry effects of the different FDI types, columns (4)-(6) add the backward and forward productivity effects of *Horizontal FDI* and columns (7)-(9) the backward productivity effects of *Parent Vertical FDI* and *Export FDI*. For reasons of space, we only report the coefficient estimates on the FDI variables. The coefficient estimates of the control variables are similar as before.

First consider the intra-industry effects. In Section 4.2.2 we formulated the expectation that the intra-industry effects of horizontal FDI would be larger than those of vertical FDI in the EU than in CUSFTA. In accordance with the earlier results, for *Horizontal FDI*, we observe a positive significant effect only when capital stocks are used in column (1), and indeed the estimated coefficient is (substantially) larger in the EU than in CUSFTA. However, adding the inter-industry effects of *Horizontal FDI* in columns (4)-(6), the effect in CUSFTA actually disappears. As before, adding the backward effects of *Parent Vertical FDI* and *Export FDI* in column (7), all the effects of *Horizontal FDI* disappear. In contrast to Table 4.3, the forward productivity effects of *Horizontal FDI* in columns (4)-(6) are no

Table 4.4: Productivity effects of horizontal and vertical FDI - Regional Integration Agreements

	(1)Capital	(2)Labor	(3)R&D	(4)Capital	(5)Labor	(6)R&D	(7)Capital	(8)Labor	(9)R&D
Horizontal FDI×CUSFTA^{a,b}	0.023*	0.008	0.005	0.015	0.002	0.011	0.056	0.003	0.017
	(.012)	(.011)	(.008)	(.031)	(.016)	(.014)	(.057)	(.017)	(.017)
Horizontal FDI×EU^{a,b}	0.045*	0.015	0.000	0.026*	0.001	0.010	0.027	0.021	0.003
	(.023)	(.017)	(.012)	(.014)	(.017)	(.016)	(.024)	(.016)	(.012)
Parent Vertical FDI×CUSFTA^{a,b}	0.025***	0.017***	0.020***	0.043***	0.047***	0.025**	0.052***	0.033**	0.027***
	(.004)	(.003)	(.005)	(.013)	(.018)	(.011)	(.017)	(.014)	(.006)
Parent Vertical FDI×EU^{a,b}	0.019***	0.012*	0.022**	0.027***	0.023***	0.021*	0.016	0.015	0.023**
	(.007)	(.006)	(.011)	(.009)	(.009)	(.012)	(.017)	(.009)	(.011)
Export FDI×CUSFTA^{a,b}	0.002	0.001	0.015	−0.004	−0.019	0.009	−0.062	−0.045	−0.017
	(.006)	(.007)	(.011)	(.023)	(.003)	(.063)	(.055)	(.030)	(.018)
Export FDI×EU^{a,b}	0.041***	0.026**	0.029*	0.036***	0.029**	0.033*	0.039***	0.029**	0.026*
	(.013)	(.011)	(.015)	(.013)	(.012)	(.017)	(.014)	(.011)	(.014)
Forward Horizontal FDI×CUSFTA^{a,b}				−0.050	−0.052	0.022			
				(.038)	(.036)	(.117)			
Forward Horizontal×EU^{a,b}				−0.030	−0.021	−0.053			
				(.024)	(.028)	(.032)			

Table 4.4 (continued)

	(1)Capital	(2)Labor	(3)R&D	(4)Capital	(5)Labor	(6)R&D	(7)Capital	(8)Labor	(9)R&D
Backward Horizontal FDI×CUSFTA^{a,b}				0.017	0.016	−0.009			
				(.013)	(.017)	(.015)			
Backward Horizontal FDI×EU^{a,b}				0.003	−0.004	0.011			
				(.010)	(.011)	(.012)			
Backward Parent Vertical FDI×CUSFTA^{a,b}							−0.001	0.022*	0.092
							(.009)	(.011)	(.072)
Backward Parent Vertical×EU^{a,b}							0.040**	0.007	0.027
							(.019)	(.010)	(.019)
Backward Export FDI×CUSFTA^{a,b}							−0.006	0.001	−0.135
							(.026)	(.012)	(.121)
Backward Export FDI×EU^{a,b}							−0.033*	−0.009	−0.022
							(.019)	(.011)	(.16)
Constant	0.297**	0.267**	0.177**	0.224***	0.196**	0.318***	0.352***	0.296***	0.265***
	(.125)	(.116)	(.088)	(.068)	(.089)	(.086)	(.119)	(.060)	(.072)
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-stat	382.9***	244.9***	232.8***	492.1***	338.5***	378.2***	542.8***	371.5***	350.0***
AR(1)	−5.10***	−5.05***	−4.86***	−4.73***	−4.30***	−4.58***	−3.52***	−4.38***	−4.98***
AR(5)	−1.11	−0.99	−1.53	−1.67*	−1.46	−1.15	0.09	−1.49	−1.05
Sargan-Hansen test	41.2	41.4	39.7	36.5	46.2	37.6	35.4	42.8	33.7
N	547	550	453	547	550	453	547	550	453

Notes: Dependent variable is (log) TFP; a) 1-period lagged values of the variables are used; b) Reported coefficients are standardized. System GMM-estimates - One step robust estimator, lags 5-6 used for endogenous variables. * $p<0.1$; ** $p<0.05$; *** $p<0.01$

longer significant.

Next consider the intra-industry effects of $Parent\ Vertical\ FDI$: In all but two models, this type of FDI has a positive and significant effect in both CUSFTA and the EU. In line with the theoretical expectations formulated in Section 4.2.2, the effect of this type of FDI is generally larger in CUSFTA than in the EU. The backward productivity effects of $Parent\ Vertical\ FDI$ in columns (7)-(9) show no consistent pattern.

Finally, the intra-industry effects of $Export\ FDI$ are never significant in CUSFTA and always positive and significant in the EU. Since $Export\ FDI$ is by definition directed towards parties in third countries, in CUSFTA it is by definition directed to outsiders, whereas in the EU it is very possibly directed to insiders. As such, CUSFTA does not change the conditions under which US MNEs can leverage their Canadian export platforms. However, due to the Single Market Program in the EU, export platforms are relatively attractive to serve insider countries within the EU. As a consequence, we would expect to see an increase in so-called "hub-and-spoke" configurations of US MNEs' affiliates in the EU, where production or research is concentrated in one or a couple of large centers, which in turn supply several (sales) subsidiaries in other (insider) countries. From such a viewpoint, the presence of positive effects of $Export\ FDI$ in the EU and its absence in CUSFTA is very plausible. As before, there are no consistent backward effects of this type of FDI in columns (7)-(9).

4.5 Discussion and conclusion

This chapter is one of the first contributions in this field to consider the market orientation of MNEs' subsidiaries as a dimension of heterogeneity that might affect its productivity effects. Specifically, we distinguish not only between horizontal and vertical FDI, but we also consider the destination of vertical FDI as an important factor, i.e. whether it is directed to the parent company (which closely resembles the theoretical setup) or whether it is directed to parties in third countries (which mainly reflects export platform FDI). In addition, to the best of our knowledge we are also the first to consider the mediating impact of Regional Integration Agreements (RIAs) on the associated productivity effects of these different FDI types.

Our theoretical model yields two main predictions: First of all, we should expect that the intra-industry effects of horizontal FDI are larger than those of vertical FDI, since horizontal FDI induces more industry-wide learning effects as it employs more (knowledge) capital abroad. Our empirical results confirm this expectation, but only when we use affiliate capital stocks as the FDI proxy and compare the results with vertical FDI directed at the parent company. For the other FDI proxies (employment and R&D stocks), the effects of horizontal FDI are largely absent.

The second main prediction of our model relates to the effect of trade costs. Specifically, we have formulated the expectation that the productivity effects of horizontal FDI will be larger in the EU, whereas those of vertical FDI will be larger in CUSFTA. Our empirical results confirm both, although the effect of horizontal FDI is again only present when affiliate capital stocks are used. Additionally, we find a consistently positive and significant effect of export platform FDI in the EU, but not in CUSFTA, which indicates that it is indeed substantially different from the more traditional vertical FDI. We explain this effect by noting that CUSFTA does not change the conditions under which US MNEs can leverage their Canadian export platforms, whereas it does for their EU subsidiaries. That is, due to the Single Market Program in the EU, export platform FDI becomes more attractive in the EU than in CUSFTA, and hence its associated productivity effects tend to be larger as well.

We have also considered the inter-industry effects of these different types of FDI, but have found no consistent effects. There is some slight indication of negative forward productivity effects of horizontal FDI, but this results is very sensitive to the inclusion of other FDI types and whether or not the two different RIAs are accounted for. A plausible explanation for the absence of consistent vertical linkage effects may be that the level of aggregation in our industries is too large to properly disentangle horizontal and vertical effects. That is, what is captured now as horizontal effects may very well also include vertical effects across industries at a lower level of aggregation. This somewhat clouds the interpretation of our results, but they nonetheless imply that at lower levels of aggregation either the horizontal or vertical effects still exist.

As a final note, there might exist an alternative explanation to our findings regarding the productivity effects of vertical FDI, and the differences between the two RIAs, which is not incorporated in the theoretical model. This explanation is offered by Keane and Feinberg (2007), who study the determinants of increased intra-firm trade between US MNE parents and their Canadian affiliates during the 1980s and part of the 1990s. They give a convincing and detailed account of the extent to which Just In Time (JIT) logistics drastically reduced inventory costs in Canadian subsidiaries, thus decreasing the costs of intra-firm trade and hence drastically increasing the extent of parent-subsidiary trade. These managerial innovations in turn might be a source of the observed productivity effects of this type of FDI in CUSFTA. Moreover, other studies suggest that the documented improvement in affiliate productivity or efficiency and the resulting increase in intra-firm trade is not necessarily limited to Canadian affiliates. Antràs and Helpman (2004) demonstrate, in a model on outsourcing versus vertical integration decisions by MNEs, that more productive parents are more likely to vertically integrate intermediate suppliers. This is essentially due to the fact that their opportunity costs of default by an outside supplier are larger (relative to less productive firms). Using intra-firm trade data between US MNE parents and their foreign affiliates in a number of host countries, Nunn and Trefler (2007) find macroeconomic empirical evidence for this. Hence, this explanation may also be applicable in the EU context that we have considered.

Appendix

In order to derive the condition under which all three firm types (n, h and v) exist simultaneously, we first have to extend the model. Specifically, we have to introduce consumers that consume the products produced by the different firms. Specifically, assume that intertemporal consumer utility is given by:

$$\int_{t=s}^{\infty} e^{-\rho(t-s)} \ln\left(C_X^{\mu} C_Z^{1-\mu}\right) \text{ where } C_X = \left(\int_{i=0}^{N_j+N_k} c_i^{(\sigma-1)/\sigma}\right)^{\sigma/(\sigma-1)}$$

where C_X and C_Z denote consumption of X and Z, where Z is a good produced under perfect competition and constant returns to scale, using only labor L. Z is the numéraire good in the model. C_X is a CES composite of individual manufacturing varieties, c_i is consumption of variety i, $\sigma > 1$ is the constant elasticity of substitution and $\rho > 0$ is the subjective rate of time preference. μ denotes the share of total income Y that is spent on manufacturing goods X and N_j and N_k are the total number of firms (of all types) active in countries j and k.

Optimization of consumption yields the following solution for consumption of the individual manufacturing varieties:

$$c_{jj} = \frac{\mu Y_j p_j^{-\sigma}}{P_j^{1-\sigma}}; c_{jk} = \frac{\mu Y_k (\tau p_j)^{-\sigma}}{P_k^{1-\sigma}}$$

$$P_j = ((n_j + h_j + h_k + v_k) p_j^{1-\sigma} + (n_k + v_j)(\tau p_j)^{1-\sigma})^{1/(1-\sigma)} \qquad \text{(A1)}$$

Additionally, a share of μ of Y is allocated to X, a share $(1-\mu)$ to Z and the Euler equation ($Y = r - \rho$) is satisfied. Substituting the values c_{jj} for x_{jj} and c_{jk} for x_{jk} in (X) and optimization yields the equilibrium pricing condition:

$$p_j = \frac{\sigma \beta w_j}{\sigma - 1}$$

In order to determine which firm types will arise, we have to compare present value Ricardian surpluses π (i.e. the rewards to K) across firm types. In the present setup, these are equal to (the present value of) operating profits $(p - \beta w)c = pc/\sigma$, since this is what is left over to reward K, after rewarding L. From the Euler equation, we know that in equilibrium the optimal discount rate is equal to ρ. Moreover, we assume that K grows at rate g. Hence the discounted value of Ricardian surplus π_i is equal to $\pi_i = (\rho + g)$ where $i = n, h$ or v. So we obtain:

$$\pi_n = \frac{\mu w_j^{1-\sigma}}{\sigma(\rho+g)} \Psi \left[\frac{Y_j}{P_j^{1-\sigma}} + \frac{\phi Y_k}{P_k^{1-\sigma}} \right]$$

$$\pi_h = \frac{\mu}{\sigma(\rho+g)} \Psi \left[\frac{w_j^{1-\sigma} Y_j}{P_j^{1-\sigma}} + \frac{w_k^{1-\sigma} Y_k}{P_k^{1-\sigma}} \right]$$

$$\pi_v = \frac{\mu w_k^{1-\sigma}}{\sigma(\rho+g)} \Psi \left[\frac{\phi Y_j}{P_j^{1-\sigma}} + \frac{Y_k}{P_k^{1-\sigma}} \right]$$

where $\Psi \equiv [\sigma\beta/(\sigma-1)]^{1-\sigma}$ and $\phi \equiv \tau^{1-\sigma} \in [0,1]$ is a freeness of trade parameter, which takes values of 0 when trade costs are prohibitive and 1 if trade is completely free.

In order for all three firm types to arise we require that their Ricardian surpluses per unit of capital are equivalent. Otherwise, one firm type could always do better becoming another firm type. Equivalence of these three expressions, divided by their relevant knowledge capital outlays implies:

$$\left[\gamma\left(\frac{Y_j P_k^{1-\sigma}}{Y_k P_j^{1-\sigma}}\right)+\phi(\gamma+1)\right]^{1/(1-\sigma)}=\frac{w_j}{w_k}=\left[\frac{\frac{Y_j}{P_j^{1-\sigma}}+\frac{\phi Y_k}{P_k^{1-\sigma}}}{\frac{\phi Y_j}{P_j^{1-\sigma}}+\frac{Y_k}{P_k^{1-\sigma}}}\right]^{1/(1-\sigma)} \tag{A2}$$

If this condition is satisfied, all three firm types exist simultaneously in equilibrium.

Table A.1: Countries and industries

Countries	Industries
Belgium	Computers & electronic products
Canada	Chemicals
Denmark	Machinery
Finland	Electrical equipment, appliances & components
France	Transportation equipment
Germany	Food & kindred products
Ireland	Primary & fabricated metals
Italy	Utilities
Netherlands	
Norway	
Spain	
Sweden	
United Kingdom	

Chapter 5

FDI Motives and productivity effects

5.1 Introduction

In the previous chapters, it was established that both the extent of MNE ownership over its foreign subsidiaries as well as the market orientation of such subsidiaries matter a great deal for the extent of intra and inter-industry knowledge diffusion, and productivity effects in general. Yet another dimension of FDI heterogeneity is that of differing FDI motives. In Section 2.5.3 we mentioned the distinction between technology exploiting FDI (hereafter TE FDI) on the one hand, and technology seeking FDI (hereafter: TS FDI) on the other. The former is the more "traditional" type, which is aimed at exploiting a firm-specific competitive asset abroad (Hymer, 1970; Dunning, 1977; Markusen, 2002). The latter, also known as strategic asset-seeking FDI (Dunning and Narula, 1995), or home-base-augmenting (Kuemmerle, 1999; Le Bas and Sierra, 2002), is instead aimed at acquiring external knowledge which resides in foreign competitor firms, and which the seeking firm itself is lacking.[50]

[49] Parts of this chapter are based on Smeets and Bosker (2008) and Cantwell and Smeets (2008).

[50] To be precise, there exist some (subtle) differences between these terms. Specifically, Le Bas and Sierra (2002) argue that technology seeking FDI is directed towards offsetting home country technological weaknesses, whereas home-base-augmenting FDI is aimed at targeting technologies in which both the host and the home country are relatively strong, so as to augment a firm's existing stock of knowledge. In order to not introduce too many

The theory behind technology seeking FDI has developed the following intuition (Kogut and Chang, 1991; Fosfuri and Motta, 1999; Siotis, 1999): firms which lack a competitive asset or technology themselves (usually referred to as laggard firms) may try to acquire this from a more advanced foreign competitor (the leader) by capturing knowledge spillovers.[51] Since knowledge spillovers are spatially bounded (Jaffe et al., 1993; Audretsch and Feldman, 1996; Almeida and Kogut, 1999), the laggard has to engage in FDI in the country of the competitor in order to benefit from these knowledge spillovers. The resulting type of FDI is called technology seeking FDI.

Many empirical papers have indeed demonstrated that laggard firms, or firms from lagging industries or countries, are most likely to engage in TS FDI (*cf.* Berry, 2006). For example, Kogut and Chang (1991) study 825 entries of Japanese firms in 165 US industries. They find that Japanese Joint Ventures (JVs) with US firms are most likely to occur when the industry-level R&D intensity of the US is high relative to Japan. The authors take this evidence to imply that Japanese-US JVs appear to be motivated by the sourcing of US technology by lagging Japanese firms. Similarly, Neven and Siotis (1996) find that US and Japanese FDI in four large EU countries is larger when the industry-level R&D intensity of the EU countries relative to the US and Japan is higher. Almeida (1996) uses patent citations of foreign subsidiaries in the US to US patents in order to track knowledge flows, and shows that European and Korean firms seek technology in the US to offset their home-country disadvantages. Chung and Alcácer (2002) investigate 1,784 FDI transactions from OECD countries into the US. They find *inter alia* that firms from lagging country-industry pairs are attracted to US states with larger R&D intensities, which they view as consistent with their expectation of knowledge-seeking behavior by technical laggards. To summarize this empirical evidence in their words: "The conventional wisdom is that knowledge seeking occurs mainly among technical laggards trying to reduce their gap by investing abroad to acquire the needed knowledge" (2002: p. 1535).

Building on these theoretical and empirical insights, Girma (2005) and Driffield and Love (2007) have argued that it can reasonably be expected that these different types of FDI will also generate different extents of knowledge

different terms, we will use the term technology seeking FDI throughout the chapter, although it can also refer to home-base-augmenting FDI in some instances.

[51] The fact that the leader is foreign implies that the laggard firm is also located in a (relatively) lagging industry or country.

diffusion to local firms: laggard firms engaging in TS FDI do not have any technology or knowledge to diffuse themselves, in sharp contrast to leader firms engaging in TE FDI. Hence, the implication is that TE FDI will lead to knowledge diffusion, whereas TS FDI will not. Indeed, both these studies find empirical support for this proposition.

These empirical findings notwithstanding, case-study evidence appears to be telling a somewhat different story. For example, in 2000, British Telecom (BT) set up a stand-alone venture fund in Silicon Valley. The task of this venture fund was to identify (start-up) companies with technologies and business solutions that were of potential interest to BT. By 2002, it had developed into a full-fledged technology scouting unit, with the task of actively identifying external technologies. In 2006, similar operations were also begun in China and Japan (Monteiro and Sull, 2006). Relatedly, Miller (1992) documents the high degree of internationalization of advanced engineering and R&D facilities of General Motors, Ford and Volkswagen to monitor concepts and ideas of foreign competitors and spot trends in foreign markets.

The firms mentioned in these examples hardly stem from lagging countries or industries, and are hardly laggards themselves. On the contrary, GM, Ford and Volkswagen are in the top-20 of the 2008 Global 500 companies list, and BT is at position 166. Apparently, the theory and findings in the academic literature regarding TS FDI are somewhat at odds with business reality. In particular, three questions arise: first, why are the leaders and not the laggards engaging in TS FDI? Second, what are the laggards doing instead to compensate their lack of competitive assets or technology? And third - and most importantly from the objective of this thesis - does this imply that TS FDI leads to knowledge diffusion after all?[52]

The aim of this chapter is to answer these three questions by developing a theory of technology seeking strategies for leader and laggard firms. We do this by taking a simple formal model developed by Siotis (1999), extending it with some recent empirical insights regarding the differences between leaders and laggards (Berry, 2006) and alternative technology seeking strategies (Salomon and Jin, 2008). Using this model, we then look at optimal (i.e. equilibrium) strategies for both leader and laggard firms. Looking ahead a little bit, we find - consistent with much of the case-study evidence and re-

[52] Note that in a leader-laggard context, the term home-base-augmenting FDI may be more suited for the leader, whereas the term technology seeking FDI seems more suited for the laggard. As mentioned in footnote 50, we will use the term technology seeking FDI in both cases, but we do not deny the difference between the two concepts.

cent econometric insights - that leaders engage both in TE FDI as well as TS FDI. We then move on to empirically investigate the implications of these findings for the difference between productivity effects between TS FDI and TE FDI, using industry-level data of the operations of US MNEs in 14 OECD countries. Again, consistent with both earlier literature and our own model, we indeed find that both TS FDI and TE FDI lead to increased productivity of local firms.

The rest of this paper is structured as follows: In Section 5.2 we extend a model by Siotis (1999) to analyze the relationship between different technology seeking strategies and leader and laggard firms. We then simulate our model in Section 5.3 to find the equilibrium outcomes. Next, we confront our theoretical results with evidence from case studies, recent econometric analyses, and some exploratory industry-level analysis in Section 5.4. After that, we move on to empirically investigate the productivity effects of TE FDI and TS FDI in Section 5.5. Finally, Section 5.6 concludes.

5.2 Theory and model

We start by pursuing the first two questions formulated above: Why are leaders and not laggards engaging in TS FDI? And what are laggards doing instead to compensate their lack of competitive assets or technology? This first calls for a description of leaders vis-à-vis laggards.

In the theory of TS FDI, a laggard firm is backward in terms of competitive assets or technology relative to the leader. This translates into low productivity for the laggard and high productivity for the leader (Fosfuri and Motta, 1999; Siotis, 1999). However, Berry (2006) argues that two other aspects should be taken into account: first, it should be acknowledged that laggards will generally possess less absorptive capacity than leaders, which makes it harder for them to absorb knowledge spillovers. Second, when laggards set up a foreign subsidiary, they are expected to have less intra-firm technology transfer skills than leaders, which makes it more difficult to transfer knowledge across firm units. Hence, our description of a laggard firm in this chapter is *a firm which has lower productivity, lower absorptive capacity and less intra-firm technology transfer skills relative to a leader.*

Our second question (what are laggards doing instead of TS FDI) implies that there are other strategies to seek external foreign knowledge. Here we draw from a rather large literature on learning by exporting (Egan and Mody, 1992; Hobday, 1995; Salomon and Jin, 2008), which argues that firms can benefit from their export relationships. Mechanisms that are often mentioned in this respect are the pressure of having to compete with foreign competitors and receiving various kinds of assistance (e.g. employee training, quality control procedures and quality standard assistance) from foreign customers (Hobday, 1995; Crespi, Criscuolo and Haskel, 2006). Hence, learning by exporting might be an alternative strategy to seek external foreign technology.

Now, consider the following model (*cf.* Siotis, 1999): There are two countries, North (N) and South (S), and two firms n (the leader) and s (the laggard). Firm n's home-country is N and firm s's home-country is S. Suppose that generic unit marginal cost functions are given by:

$$h_i = c - a_i \tag{5.1}$$

where c is a (country-specific) per-unit fixed cost and a_i is the technology parameter of firm $i = n, s$. Hence, a_i can be thought of as the competitive or technology asset of the firm. The larger is a_i, the smaller are unit marginal costs h_i. Given the first part of our definition of a laggard firm above and the fact that s is the laggard, it is implied that $a_n > a_s$.

We also define a variable z as follows: $z \equiv (a_i/a_n)$; $i = s, n$. In line with previous literature (*cf.* Blomström et al., 2000) we argue that z is related to absorptive capacity: That is, the lower is z, the lower is absorptive capacity. Note that this takes care of the second part of our definition of a laggard firm, since absorptive capacity z is always lower for firm s than for firm n given that $a_n > a_s$.[53]

The model entails two periods. In period 1, both firms have to choose an internationalization strategy which allows them to seek technology abroad. Each firm can choose between exports (e) or FDI (f). Hence, a firm's strategy set σ in period 1 is given by $\sigma \in \{e, f\}$.

If a firm decides to export its products abroad, it incurs an iceberg transport cost of $t \geq 1$.[54] As explained above, the firm can learn from exporting, so that it obtains a knowledge spillover of magnitude ρ ($0 \leq \rho \leq 1$). Knowledge spillovers enter the marginal cost function of firm n (s) as in d'Aspremont and Jacquemin (1988):

$$h_i = c - a_i - z\rho a_j \tag{5.2}$$

[53] That is, for the n firm $z = 1$, whereas for the s firm $z < 1$.

[54] The name iceberg transport cost derives its name from the idea that part of the goods that are shipped melt away in transit. Hence, to deliver an amount q, somewhat more has to be shipped ($t \times q$).

such that $i, j = n, s$ and $i \neq j$. Hence, by engaging in exports, a firm i obtains a share ρ of its foreign competitor's technology stock a_j, regardless of the strategy chosen by the competitor. However, the effective knowledge spillover also depends on the absorptive capacity z of the firm (Cohen and Levinthal, 1989; Minbaeva, Pedersen, Björkman, Fey and Park, 2003; Berry, 2006). The lower z (i.e. the lower absorptive capacity), the lower are effective spillovers (*cf.* Blomström et al., 2000).

If a firm decides to engage in FDI in period 1, it incurs a fixed setup cost C which is country specific. In this case, it will capture a share ϕ $(0 \leq \phi \leq 1)$ of the other firm's knowledge stock, again contingent on its absorptive capacity z. Doing justice to the large literature on the spatiality of knowledge spillovers (e.g. Almeida and Kogut, 1999; Audretsch and Feldman, 1996; Jaffe et al., 1993; Keller, 2002), we assume that knowledge spillovers obtained through exports will be lower than those obtained through FDI , i.e. $\rho < \phi$.

In order to capture the third and final part of our definition of a laggard firm, we also introduce intra-firm technology transfer skills in the case of FDI. Hence, any spillovers that are captured by the foreign subsidiary can be transferred back to the parent firm at some cost. Specifically, we assume that a share λ $(0 \leq \lambda \leq 1)$ of total spillovers captured by the foreign subsidiary is successfully transferred back home. Also, technology transfer from the parent firm to its subsidiary is costly: only a share μ $(0 \leq \mu \leq 1)$ of the original knowledge stock is successfully transferred abroad.[55] Hence, if firm s engages in FDI, this results in the following unit marginal costs functions (where asterisks denote values in country S):

$$\begin{aligned} h_s &= c - \mu_s a_s - z\phi a_n \\ h_s^* &= c^* - a_s - z\phi\lambda_s a_n \end{aligned} \tag{5.3}$$

Subscripting λ and μ by $i = n, s$ takes care of the third part of our definition of a laggard firm also being less skilled in transferring knowledge across firm units than a leader (i.e. $\lambda_s < \lambda_n$ and $\mu_s < \mu_n$).[56]

[55]Note that we could also let λ,μ >1, which would imply that the subsidiary is not just transferring knowledge but also creating knowledge of its own, using the external knowledge it captures abroad (*cf.* Almeida and Phene, 2004; Cantwell and Mudambi, 2005; Phene and Almeida, 2008). However, since we are mainly interested in (differences in) technology transfer skill, the proposed upper boundary of 1 is more natural. Moreover, below we normalize λ_n (μ_n) to 1 so that λ_s (μ_s) captures the technology transfer skill-gap between the leader and the laggard. In this case, the boundaries on λ and μ are irrelevant.

[56]This way of modeling parent-subsidiary relationships and the resulting cost-structures

The implications of all of the above for the different marginal cost functions are summarized in Table 5.1 below.

Table 5.1: Marginal cost functions

n, s export	n, s FDI	n export, s FDI	n FDI, s export
$h_n = c - a_n - \rho a_s$	$h_n = c - a_n - \phi\lambda_n a_s$	$h_n = c - a_n - \rho a_s$	$h_n = c - a_n - \phi\lambda_n a_s$
$h_s = c^* - a_s - z\rho a_n$	$h_s = c - \mu_s a_s - z\phi a_n$	$h_s = c - \mu_s a_s - z\phi a_n$	$h_s = c^* - a_s - z\rho a_n$
$h_n^* = c - a_n - \rho a_s$	$h_n^* = c^* - \mu_n a_n - \phi a_s$	$h_n^* = c - a_n - \rho a_s$	$h_n^* = c^* - \mu_n a_n - \phi a_s$
$h_s^* = c^* - a_s - z\rho a_n$	$h_s^* = c^* - a_s - z\phi\lambda_s a_n$	$h_s^* = c^* - a_s - z\lambda_s\phi a_n$	$h_s^* = c^* - a_s - z\rho a_n$

From the formulation of marginal costs it follows that firms do not receive knowledge spillovers automatically. For example, if firm n engages in FDI and firm s in exports, we assume that firm s only receives knowledge spillovers through its own exporting activities, and not from firm n's foreign subsidiary that is present in S. This implies that firm s's marginal cost in S are given by $h_s^* = c^* - a_s - z\rho a_n$ instead of $h_s^* = c^* - a_s - za_n(\rho + \mu_n\phi)$. This assumption is based on the fact that firms have to undertake explicit technology seeking efforts to benefit from knowledge spillovers. Consequently, if they export, they will only benefit from the related spillovers ρ. Alternatively, if they undertake FDI, they will only benefit from knowledge spillovers in the host country.[57]

In period 2, the two firms play Cournot and earn profits. The precise formulation of the inverse demand functions that firms face depends on the period 1-strategies chosen by them. If firm s (n) decides to engage in FDI,

is very similar to that employed in Mudambi and Navarra (2004) (specifically Figure 1, p. 389 in that paper). One crucial difference is that we do not consider internal knowledge creation by the subsidiary in our model (*cf.* footnote 55).

[57] This way of modelling technology seeking effort thus assumes that being spatially proximate does not automatically generate spillovers ϕ. An alternative approach would be to consider explicit R&D decentralization from the parent to the subsidiary as a necessary condition for technology seeking through FDI (Sanna-Randaccio and Veugelers, 2007). However, we would then have to model an additional R&D decentralization stage. We prefer this simpler setup, since our main focus is on the technology seeking strategy decision.

inverse demand in N (S) is given by:[58]

$$\begin{aligned} p &= \alpha - \frac{q_n}{S_N} - \frac{q_s}{S_N} \\ p^* &= \alpha - \frac{q_s^*}{S_S} - \frac{q_n^*}{S_S} \end{aligned} \tag{5.4}$$

where p denotes price, α is a demand parameter, q_n (q_s) denotes demand for products by firm n (s) and S_N (S_S) measure market size in N (S). Asterisks denote values in S. In case firm s (n) decides to export, inverse demand functions become:

$$\begin{aligned} p &= \alpha - \frac{q_n}{S_N} - \frac{q_s}{S_N/t} \\ p^* &= \alpha - \frac{q_s^*}{S_S} - \frac{q_n^*}{S_S/t} \end{aligned} \tag{5.5}$$

Profits for firm n, contingent on firm s's strategy σ_s and its own strategy σ_n are denoted by $\Pi_n^{\sigma_n\sigma_s}$. They are derived from the fact that firms' strategies are best responses to each other, and that firms maximize profits in equilibrium. This yields eight explicit profit functions, which are relegated to the Appendix of this chapter

5.3 Equilibrium Strategies

5.3.1 Simulation results

In order to analyze the Subgame Perfect Nash Equilibria (SPNE) of this game we have to simulate the model, as it is not analytically solvable.[59] Since we are interested in the interplay between technology seeking (via spillovers) and firm heterogeneity (via productivity differences, absorptive capacity and intra-firm technology transfer skill) and their consequences for equilibrium

[58] For a formal proof on the derivation of these demand curves, see Motta (1996).

[59] This is due to the strategic interaction in the model, which implies that both firms choose their optimal strategies simultaneously. Using e.g. Stackelberg leadership as a solution concept would give us closed form solutions (see Brojvatn and Eckel, 2006 for an analysis in this context). Since first-mover advantages are not our primary concern here, we use SPNE as the solution concept.

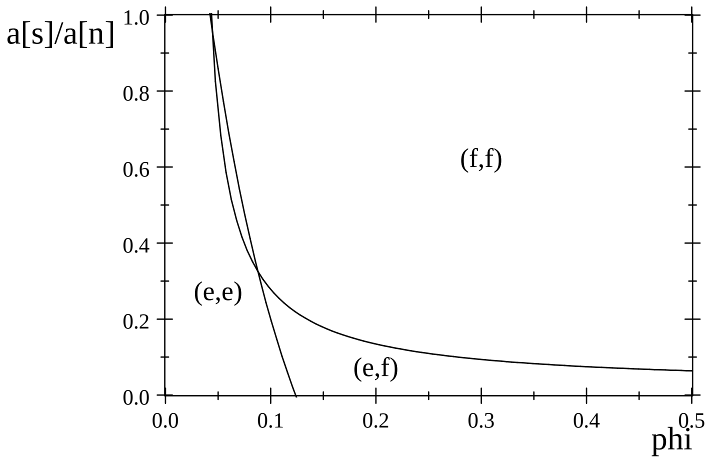


Figure 5.1: Perfect intra-firm technology transfer

strategies, we let these parameters vary and fix the others.[60] We will consider two scenarios: First, we limit leader-laggard heterogeneity to their technological capabilities (i.e. productivity). Next, we will add imperfect intra-firm technology transfer costs and absorptive capacity to the model to see how extending firm heterogeneity along these lines alters the model outcomes.

Scenario 1: Perfect knowledge transfer & absorptive capacity

Figure 5.1 sets $\mu_i = \lambda_i = 1$ $(i = n, s)$ and $z = 1$ in the MC functions in Table 5.1. In the figure (σ_n, σ_s) denotes the SPNE in which firm n (s) plays strategy σ_n (σ_s) in period 1, where $\sigma \in \{e, f\}$.

If knowledge spillovers are relatively low, both firms prefer to export their products abroad, regardless of the technology gap. In this way they do not

[60]In general, we require that all profits are nonnegative, i.e. that $\alpha > 2c^* - c - a_i(2z\phi\lambda_j - 1) - a_j(2-\rho)$ (see Appendix) and that market size S_i is positive for $i = N, S$. In line with this requirement (and Siotis' (1999) simulated parameter settings) we set $\alpha = 5$, $c = c^* = 2$, $a_n = 1$, $\rho = \phi/4$, $t = 1.05$, $S_N = S_S = 100$ and $C = C^* = 20$. Note that $z \equiv a_s/a_n = a_s$ in this case. Values for t and C are chosen such that equilibrium results are not solely determined by the usual proximity-concentration trade-off (Brainard, 1997). In this way, we can explicitly focus on the technology seeking motives of both firms.

incur fixed setup costs, while still benefiting from spillovers, although these are smaller than those obtained through FDI. Yet, as knowledge spillovers increase, the laggard firm soon finds it more profitable to seek technology abroad via FDI, despite the fixed costs: the increase in spillovers increases the opportunity costs of exporting, since local spillovers ρ are by assumption smaller (or have a smaller impact on marginal costs) than spillovers obtained through FDI (ϕ). Since intra-firm technology transfer skills and absorptive capacity are perfect, the technology gap between the leader and the laggard is only to the laggard's advantage: the larger the gap, the larger the relative gain, both for the subsidiary as well as the parent.

A similar mechanism is at work for the leader, but the technology gap has to decrease first before the leader will find it profitable to engage in FDI. The reason is that the technology gap initially works to the leader's disadvantage: for a large technology gap, there is relatively little to gain by absorbing spillovers from the laggard, but relatively a lot to lose by spilling over knowledge to the laggard. Consequently, the benefits from higher spillovers through FDI are not sufficient to compensate fixed costs of FDI if the technology gap is too large.

From Figure 5.1 it follows that there still is a large range of combinations for z and ϕ in which both the laggard firm and the leader firm engage in technology seeking FDI. This would imply that the two strands of empirical literature on firm heterogeneity and technology seeking FDI, as discussed in the introduction of this chapter, both have it right. However, thus far we have assumed that leader-laggard heterogeneity is limited to productivity (or technological capabilities). That is, we have assumed that intra-firm technology transfer of the laggard is perfect, and that absorptive capacity of the laggard is unlimited. In the next scenario, we will depart from these assumptions.

Scenario 2: Imperfect knowledge transfer & absorptive capacity

We retain the assumption that $\lambda_n = \mu_n = 1$ so that λ_s and μ_s can be interpreted as the intra-firm technology transfer skill gap of the laggard relative to the leader. The question is at what values we should calibrate λ_s and μ_s. Unfortunately, we are not aware of any study that might give us some

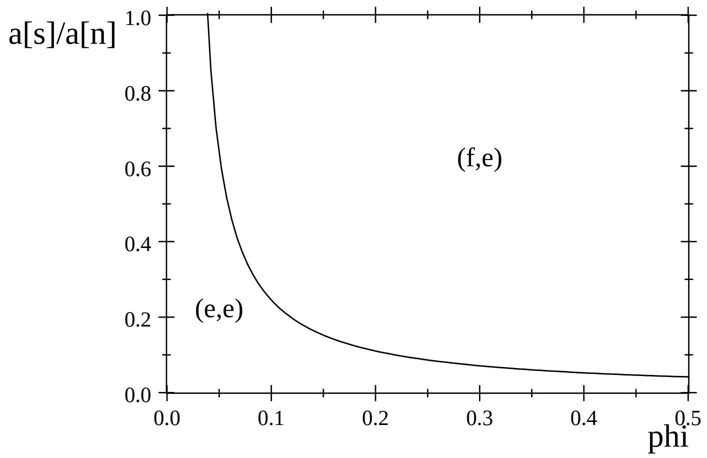


Figure 5.2: Asymmetric intra-firm technology transfer

clues on this issue.[61] At this point, we choose the rather arbitrary values of $\lambda_s = \mu_s = 0.5$, i.e. the laggard possesses 50% of the intra-firm knowledge transfer capabilities of the leader. We will investigate the sensitivity of the results with respect to λ_s and μ_s below. Additionally, we also introduce imperfect absorptive capacity (i.e. $z \leq 1$) of the laggard (*cf.* Table 5.1). Figure 5.2 gives the resulting equilibrium configuration.

The results change drastically in this case. For the laggard firm, we see that it chooses to engage in exports for all parameter combinations. For high technology gap (z), the laggard has too small absorptive capacity to benefit from the spillovers generated by the leader. Moreover, due to the high intra-firm technology transfer costs, the opportunity costs of engaging

[61] There is a study by Fors (1997) who investigates the parent-firm rate of return on R&D generated by its subsidiary and vice versa, in sample of 121 Swedish MNEs. He finds that of the technology generated by a MNE parent, about one-fifth is employed in its foreign subsidiaries. Conversely, of the technology generated and acquired in the subsidiaries, no significant amount is re-employed in the parent. Accordingly, we could calibrate the parameters as λ_s=0 and μ_s=0.2. However, one problem is that Fors' study does not only pertain to low-productivity firms, so that these values may not be applicable. Second, with λ_s=0, the technology seeking benefit of FDI is restricted to the subsidiary, as no amount of knowledge can be transferred back to the parents. This would already *ex ante* induce any kind of firm interested in technology seeking to do so through exports, which obviously rules out any interesting comparisons between exports and FDI.

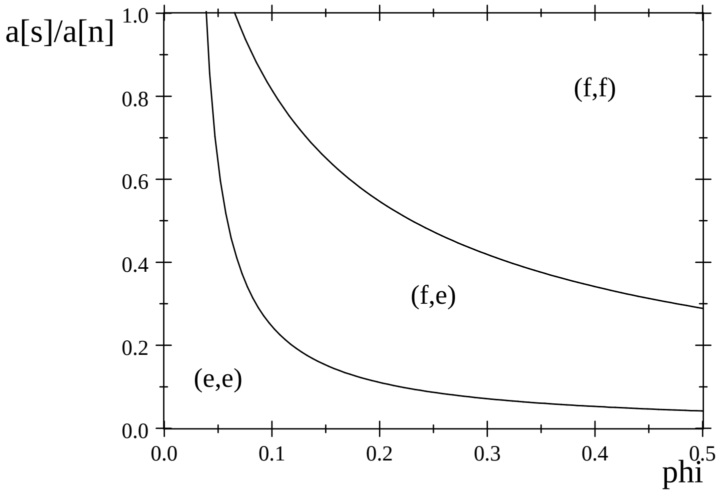
in FDI are simply too high for the laggard firm: on the one hand, technology exploitation through FDI is difficult due to $\mu_s = 0.5$. On the other hand, technology seeking through FDI is of smaller benefit to the parent since $\lambda_s = 0.5$. These effects work regardless of the technology gap, so that it is not beneficial for the laggard to engage in FDI.

Starting from the left-axis of Figure 5.2, the leader firm initially also chooses exports as a response to a similar strategy of the laggard. The reason is that knowledge spillovers are very low and, consequently, the fixed setup costs in case of FDI outweigh the higher spillovers obtained through technology seeking. However, if the extent of knowledge spillovers increases, the leader will remain an exporter only for an increasingly larger technology gap. Only in case of large technological distance do the benefits of increased spillovers from the laggard not compensate sufficiently for the fixed setup costs of FDI. Indeed, as soon as the technology gap reaches a (relatively low) threshold level, the leader finds it optimal to engage in FDI and capture larger spillovers.

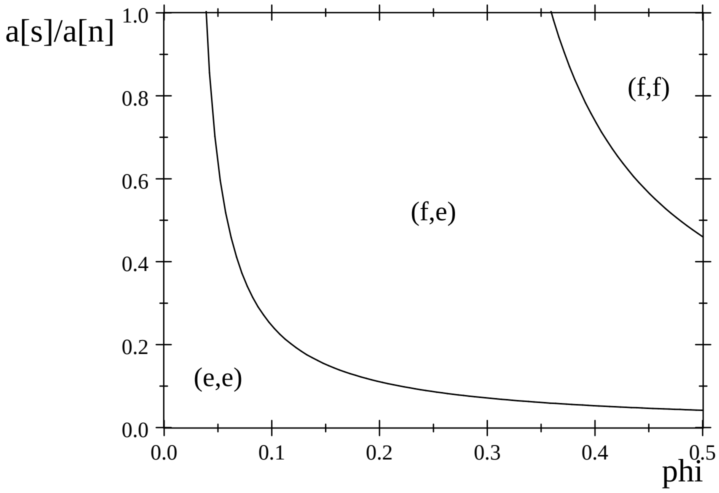
Sensitivity analysis

The results in scenario 2 already illustrate the sensitivity of the simulation results with respect to changes in μ_s and λ_s. A further decrease in μ_s or λ_s would leave the results of Figure 5.2 unaltered, as the laggard firm is already exporting for all possible parameter combinations. An increase in μ_s or λ_s however would serve to decrease the (f, e) region, as the (f, f) region would slowly enter from the North-East. In order to illustrate this latter point, as well as to shed light on the differences of increasing either μ_s or λ_s, Figure 5.3 presents two variations on Figure 5.2. In panel a, λ_s is still fixed at 0.5 but μ_s is increased to 1 whereas in panel b μ_s is fixed at 0.5 an λ_s increased to 1.

Comparison of the two panels demonstrates that increasing μ_s to 1 gives a much larger ranger of equilibria in which the laggard engages in FDI than when increasing λ_s to 1. The implication of this result is that technology exploitation is a much more dominant motive in a laggard's internationalization process than technology seeking. This can be seen by noting that increasing λ_s serves to increase the extent to which the parent-firm can benefit from the spillovers picked up by the subsidiary, whereas increasing μ_s allows the subsidiary to exploit the parents technology (Yang, Mudambi & Meyer, 2008). From Figure 5.3 it follows that even if technology transfer



a: $\lambda_s = 0.5; \mu_s = 1$



b: $\lambda_s = 1; \mu_s = 0.5$

Figure 5.3: Assymetric parent-subsidiary and subsidiary-parent technology transfer

skills from the subsidiary back to the parent are on a par with those of the leader, the laggard will still opt for exports as a technology seeking strategy for a large combination of parameter values, given that its technology exploitation skills of FDI are less developed. This clearly demonstrates the persistence of exports as a technology seeking strategy on behalf of laggard firms. For the leader, equilibrium strategies remain the same as in scenario 2.

5.3.2 Analytical results

In order to get a more general flavor regarding the relationship between firm heterogeneity and technology seeking strategies and the influence of intra-firm technology transfer skills, we now turn to some comparative static exercises. First consider the situation in which the leader exports ($\sigma_n = e$). We want to determine under which condition the laggard exports as well, i.e. under which condition it holds that $\Pi_s^{ee} > \Pi_s^{ef}$ (see Appendix). We normalize a_n to 1 so that $z \equiv a_s/a_n = a_s$. Furthermore, to keep the analysis tractable, we assume $c = c^*$, $S_N = S_S$ and normalize C to 0. Comparing the relevant profit conditions and rearranging terms yields the following condition under which $\Pi_s^{ee} > \Pi_s^{ef}$:

$$z < z_1 = \frac{(\alpha - c - 1)(2 + \Theta)}{2\mu_s + \phi(1 + 2\lambda_s) - \rho(2 + \Theta) - 2\Theta} \tag{5.6}$$

where $\Theta \equiv \sqrt{(1+t)/t}$.[62] z_1 thus describes the locus which divides the regions (e, e) and (e, f) in Figure 5.1. This condition states that once the technological gap falls below a certain threshold level z_1, the laggard firm chooses to export instead of FDI, conditional on the leader exporting as well. Note that z_1 increases with a decrease in laggard technology transfer skills μ_s and λ_s, i.e. $dz_1/d\mu_s < 0$ and $dz_1/d\lambda_s < 0$.[63] A decrease in μ_s decreases the extent to which firm j's subsidiary can exploit its technological advantage, so that a decrease in μ_s has to be compensated by a sufficient increase in relative technological ability z for FDI to still be profitable. A decrease in λ_s depresses the benefits of FDI since it allows less of the captured spillovers to

[62] Note that since by definition $t \geq 1$, $\Theta \leq \sqrt{2}$ and that $\lim_{t\to\infty} \Theta = 1$

[63] This holds under the assumption that the term $(\alpha - c - 1)$ in the numerator of (5.6) is positive, which always holds under the assumption of nonnegative equilibrium profits (cf. footnote 60). The same applies to $(2\alpha - 2c - \mu_i - 1)$ in condition (5.7) below.

be transferred back to the parent. Hence, a sufficient increase in absorptive capacity z is required to offset this effect and still make technology seeking through FDI profitable.

We can also derive the effects of the other parameters on z_1. An increase in the extent of knowledge spillovers captured through exports ρ serves to increase z_1 ($dz_1/d\rho > 0$) since it decreases the opportunity costs of exports, given ϕ. The opposite holds for an increase in ϕ ($dz_1/d\phi < 0$), since this increases the opportunity costs of exports, given ρ. Finally, an increase in transport costs t serves to decrease the threshold-level z_1 (see the Appendix for a derivation). The reason is that an increase in t makes exports less attractive than FDI. This captures the well-known tariff-jumping motive for FDI.

Second, we investigate under which condition the laggard will export, given that the leader engages in FDI. That is, we are now interested under what condition $\Pi_s^{fe} > \Pi_s^{ff}$ holds. Again comparing the relevant profit functions in the Appendix and rearranging gives:

$$z < z_2 = \frac{(2\alpha - 2c - \mu_n - 1)(1+\Theta)}{2\phi(1+\lambda_s) + 2(\mu_s + 1) - 4(\rho+1)\Theta - \phi(\lambda_n + 1)(1+\Theta)} \tag{5.7}$$

As before, decreases in λ_s and μ_s serve to increase z_2 as well ($dz_2/d\lambda_s < 0$; $dz_2/d\mu_s < 0$), and the reasons are of course similar. Also, an increase in ρ again decreases the opportunity costs of local technology sourcing, thus increasing z_2 ($dz_2/d\rho > 0$).

However, the effect of an increase in the knowledge spillovers captured through foreign technology sourcing ϕ is ambiguous in this case. Specifically, sign $dz_2/d\phi =$ sign $[(1+\lambda_n)(1+\Theta) - 2(1+\lambda_s)]$. Consider the case in which transport costs are very high (i.e. $\Theta \to 1$). In this case, $dz_2/d\phi > 0$ iff $\lambda_n > \lambda_s$. That is, if and only if the technology transfer skill of the leader is higher than that of the laggard, an increase in knowledge spillovers ϕ will increase the range of technology gaps for which a laggard still engages in exports. The reason is that in this case, not only are knowledge spillovers increasing, but the leader's subsidiary is also better able to transfer the captured external knowledge back to its parent and hence increase competition with firm s in country N as well. In order for FDI to still be beneficial in this case, the laggard needs sufficient absorptive capacity z to make up for the technology transfer skill-gap. A decrease in transport costs (an increase in Θ) will obviously make this condition less restrictive, because the opportunity costs of exports decrease with a decrease in t.

Since we are assuming that firm n engages in FDI, we can also infer the direct effect of changing the leader's intra-firm technology transfer skills. Note that an increase in μ_n decreases z_2 ($dz_2/d\mu_n < 0$): the reason is that due to the increase in μ_n, the level of the leader's technology stock exploited in its subsidiary increases, hence making firm n more competitive in country S. As a consequence, firm s needs to capture larger knowledge spillovers through FDI and become more competitive, for a larger range of technology gaps z. The opposite holds for an increase in λ_n as this serves to increase the threshold-level z_2 ($dz_2/d\lambda_n > 0$): in this case, the leader is better able to transfer knowledge spillovers captured by its subsidiary back to the parent, thus making firm n more competitive in country N. This in turn requires a smaller technology gap (higher z) for the laggard in order to still be competitive in country N as well, given that intra-firm technology transfer is imperfect. Finally, as before, an increase in transport costs t unambiguously decreases z_2 (see the Appendix for a derivation).

The results derived above are summarized in the following proposition:

Proposition 1 *If countries are similar in terms of investment environment ($c = c^*$) and market size ($S_N = S_S$), laggard firms will sooner choose exports over FDI as a technology seeking strategy if:*

a) Technology transfer skills of the laggard firm decrease, either from the parent to its subsidiary (μ_s) or from the subsidiary to the parent (λ_s);

b) Technology transfer skills of the leader firm from the parent to its subsidiary (μ_n) decrease;

c) Technology transfer skills of the leader firm from the subsidiary to the parent (λ_n) increase;

d) Knowledge spillovers obtained through local technology sourcing (ρ) increase;

e) Knowledge spillovers obtained through foreign technology sourcing (ϕ) decrease, given that $\lambda_n > [2\lambda_s + (1 - \Theta)] / (1 + \Theta)$ in case $\sigma_n = f$;

f) Transport costs (t) decrease.

Taken together, these results enable us two answer the first two questions that we set out to address: why do leaders and not laggards engage in TS FDI, and what are laggards doing instead to compensate their lack of competitive assets or technology? The answer to the first question is that apart from being more productive, leaders also benefit from higher absorptive capacity and better intra-firm technology transfer skills than laggard firms. As we saw above, these latter two factors make FDI a more attractive and feasible strategy to seek external foreign technology for the leader than for the laggard. The answer to the second question is that laggards instead use exports as a channel to seek external foreign technology, since this strategy better fits their laggard nature.

At this point, we would briefly like to reiterate some of the crucial assumptions that lead to these results: first of all, we have assumed that spillovers obtained through FDI are larger than those obtained through exports, due to the limited geographic scope of spillovers (Almeida and Kogut, 1999; Audretsch and Feldman, 1996). Second, we have assumed that in order to benefit from competitors' spillovers, an explicit technology seeking effort has to be made. That is, firms cannot benefit from them automatically (Cantwell and Mudambi, 2005; Marin and Bell, 2007; Sanna-Randaccio and Veugelers, 2007). Third, the outcomes of scenario 2 are somewhat sensitive to changing the extent of the laggard's intra-firm technology transfer skills. As such, any of the equilibrium results depicted in Figure 5.2 and Figure 5.3 may still hold in practice. Therefore, we now turn to review some of the existing empirical evidence and see how our theoretical results hold up.

5.4 The empirical evidence

Although we believe that the assumptions we have made in our model are fairly well-established in the existing literature, their validity and the outcomes of our model are in the end still an empirical matter. In this section we will first give some case examples of leading and lagging companies and their technology seeking strategies, and look at some recent econometric evidence regarding this issue. Second, we will provide a preliminary and exploratory illustration of our theoretical results using industry-level data in combination with US patent-citations data.

5.4.1 Case examples and existing econometric evidence

Our most important theoretical results (from scenario 2) indicate that leaders are more likely to engage in FDI to seek technology whereas laggards tend to do so through exports. In the introduction we already mentioned British Telecom (BT) as an example of a leader firm choosing FDI as a technology seeking strategy (Monteiro and Sull, 2006). Indeed, from its birth in 2000 the venture fund in Silicon Valley soon developed into a full-fledged technology scouting unit. The local team had to posses a high degree of both technical and communication skills in order to be able to identify useful external technologies. But the team's task went further than just pinpointing interesting developments: They also had to translate them and their business consequences into "BT language".

On top of this, there were additional tasks and skill-requirements that related to intra-firm technology transfer: the Silicon Valley team had to continuously understand the real needs of the business lines of BT in the UK and moreover, be able to "sell" the external technologies internally. Or, in the words of BT's vice president of the external innovation unit: "It takes that kind of multi faceted approach to know the priorities in the company. [...]. Being able to identify the mapping of what you see with the various interests is the challenge here" (Monteiro and Sull, 2006: p. 11). So indeed, it appears that the combination of BT's productivity leadership and high absorptive capacity and technology-transfer skills of the technology scouting team enabled it to seek technology through FDI, and to repeat this strategy for China and India in 2006.

Hansen and Birkinshaw (2007) document a similar strategy undertaken by Siemens, a top-50 2008 Global Fortune 500 company. This company sited a 15-person technology scouting unit in Berkeley, California in 1999, with the task of searching for potentially relevant external technologies, and match these to specific Siemens businesses. The authors also stress the importance of intra-firm technology transfer skills when pursuing such a technology seeking strategy: "A complementary approach to generating new ideas from outside companies is to build cross-unit networks inside organizations. After all, employees who don't know one another can't collaborate on new ideas" (2007: p. 8).

Miller (1992) mentions GM, Ford and Volkswagen as examples of (global) leaders in the automobile industry that engage in technology seeking FDI. In the automobile industry, there is a crucial distinction between the "underbody" and the "upper-body" of a car. The under-body is quite universal, so that both its R&D and production can be concentrated in one or a couple of locations. However, the upper-body is much more sensitive to (regional) trends, which has led the leading manufacturers to set up scouting units in e.g. Italy and California. On top of that, they also set up advanced engineering units in so-called "pockets of innovation" such as Brussels (in

Belgium) or Germany. Miller (1995) indeed mentions that to form a global R&D network such as that of Ford, it is very important – but difficult – to have proper inter-unit coordination and communication, so that there is sufficient intra-firm technology transfer. Moreover, he also mentions sufficient production scale as another requirement to viably run foreign technology seeking units. Indeed, minimum scale requirements would yet be another reason why leaders are more likely to engage in TS FDI than laggards. Many other instances of TS FDI on behalf of leader firms are documented in *inter alia* Dalton and Serapio (1993) and Florida and Kenney (1994).

Regarding laggard firms that engage in technology seeking through exports, Hobday (1995) mentions numerous examples from the electronics industry in East Asia. Anam Industrial, a South Korean company specializing in chip packaging, started its business in 1968. Even though the South Korean government by that time begun initiating policies to foster the development of chaebols and stabilize the macroeconomic environment, wide-spread market failures in the preceding decades had largely disconnected the country from developments in advanced countries. Consequently, at its start, Anam found itself to be lagging heavily in terms of e.g. assembly techniques, quality control and product development. Hobday (1995) documents how Anam quickly after its start began exporting its products to US clients. Initially, major US clients (such as Texas Instruments) provided *inter alia* engineering back-up and detailed product specifications. In due course, they began assisting Anam with in-house process work to ensure quality standards, productivity and delivery. The author notes: "To gain the skills [...] Anam invested heavily in engineering training and worked jointly with several of its largest customers" (1995: p. 75). All these efforts culminated into the set up of an R&D department in 1984. By now, Anam is one of the world's largest chip packaging companies with net sales close to US $ 3 billion in 2007.

Koesmawan (1995) studies 19 Indonesian textile factories, which are heavily lagging in terms of sales, capital intensity and labour productivity relative to their foreign counterparts. He describes how factories that exported their fabrics to Europe and the US significantly gained in terms of quality control processes: they started to adhere to very specific quality benchmarks, usually expressed in the maximum number of allowed defects per 100 yards of cloth produced. Large US and European customers assisted with implementing these quality control processes, ultimately of course to their own benefit. However, during interviews, representatives of these customer firms also indicated the difficulties that they experienced in this process due to low absorptive capacity of the Indonesian workforce, stressing *inter alia* the lack of technical knowledge and English language skills of the Indonesian engineers.

Indeed, in an excellent study of processes of innovation development in South-Korea, Kim (1997) repeatedly documents the necessity of sufficient absorptive capacity in order for firms to switch from an export-based technology seeking strategy, to a FDI-based technology seeking strategy. For example, in describing the process leading up to the establishment of Hyundai's American Technical Center Inc. in Ann Arbor in 1986 – set up to monitor technological change – Kim notes the substantial efforts that Hyundai spent on internal human capital development. Regarding the adoption of computer-aided design/computer-aided manufacturing (CAD/CAM) he notes how the company in 1979 assembled a team which "[...] collected literature and catalogs on CAD/CAM and spent the next fourteen months internalizing explicit literature into tacit knowledge. [...] The team was then expanded to include two or three representatives from each department that would be affected by the CAD/CAM system, 'socializing' the tacit knowledge of the original members to the new members. During the next nineteen months [the team] undertook a comprehensive study of available alternative software packages" (Kim, 1997: p. 118).

These case examples provide real-world evidence for our theoretical results. On the other hand, their implications are hard to generalize outside their particular contexts. Fortunately, there are also some recent econometric studies that tend to corroborate our theoretical results. The most appropriate study in this respect is by Berry (2006). In a sample of 631 Japanese manufacturing firms investing in OECD countries, she directly addresses the question of technology seeking FDI by either leaders or laggards. She finds that Japanese firms with R&D intensities (RDIs) above the OECD average (i.e. leaders) are more likely to set up foreign R&D labs than those with RDIs below the OECD average (i.e. laggards). Cantwell and Janne (1999) demonstrate that firms from leading technical centers in Europe locate R&D labs abroad in order to seek more diverse knowledge. Chung and Alcácer (2002) also document evidence of technical leaders engaging in TS FDI in the US pharmaceutical industry, although leadership is determined at the country-industry level in their study.[64]

[64] Although not primarily concerned with TS FDI, in a study of patents by US subsidiaries of foreign firms, Frost (2001) finds that increased technical leadership of a sub-

On the part of laggard firms, we know of no study that investigates technology seeking (or learning) through exports at the firm level in this particular context (i.e. focusing on firm heterogeneity and learning by exporting). However, Salomon and Jin (2008) do provide some evidence of our theoretical results at the industry level. Using a panel of Spanish firms, they investigate whether firms from leading or lagging industries stand to gain the most from exports in terms of productivity increases. Their results demonstrate that firms from lagging industries benefit most from knowledge spillovers through this activity. Although not all firms in lagging industries need to be laggards themselves, these results are at least indicative of our theoretical outcomes.

5.4.2 Exploratory industry-level analysis

To the best of our knowledge, there are no studies that empirically investigate the relationship between firm heterogeneity - or more specifically, leaders and laggards - and technology seeking through FDI and exports. As a preliminary and exploratory illustration of our model's outcomes, we will present some original industry-level empirical results. As mentioned by Shan and Song (1998) and Berry (2006), and as indicated in the previous (sub)section, looking at leadership and laggardship at the industry level veils a large amount of firm-level heterogeneity. A large number of firms in on average leading industries could still be laggards, and vice versa for laggard industries. While we acknowledge these objections, the lack of firm-level data, combined with our desire to at least illustrate our theoretical propositions, leads us to briefly conduct some very exploratory analyses at the industry-level.

We employ the NBER patent citations database (Jaffe and Trajtenberg, 2002) and consider those patents granted to firms from 27 non-US OECD countries during the period 1987-1999 (see the Appendix for a list of countries). We then construct two variables at the patent-level: (1) cit_{US}, measuring the absolute number of citations made by each patent to a US patent; (2) rel_cit_{US}, measuring the relative share of citations made by each patent to a US patent (i.e. the ratio of citations made to US patents over total citations made). A positive value for each of these variables indicates some degree of US knowledge seeking by the foreign firm to which the patent was

sidiary increases the extent to which the subsidiary seeks knowledge in its host location. Although leadership in this study relates to the subsidiary (and therefore is an *ex post* rather than an *ex ante* concept), these results are nonetheless illustrative of our theory.

granted (Griffith, Harrison and Van Reenen, 2006).[65]

We also use information about the country of first inventor, mentioned on each patent. In line with earlier studies (Almeida, 1996; Almeida and Kogut, 1999; Branstetter, 2006; Singh, 2007), we assume that if the country of first inventor is the US, the innovation or innovative process also took place in the US. Similarly, if the country of first inventor is the assignee's (i.e. the applying firm's) home country, we assume that the firm applying for the US patent conducted the innovation at home (Frost, 2001). Consequently, we are able to assign each patent a value of 0 (at home) or 1 (within US). Conditional on the fact that there is a positive number of citations to US patents (i.e. $cit_{US} \geq 1$ and $rel\_cit_{US} > 0$), this binary variable is our dependent variable Technology Seeking Strategy (TSS), and measures technology seeking through FDI – i.e. from within the US – ($TSS = 1$) or from the firm's home country ($TSS = 0$).[66]

Using the ANBERD and STAN databases from the OECD, we collect industry-level data on R&D stocks and value added (computed in millions of constant 1995 PPP US \$), and then construct relative R&D intensities (RRDIs) as follows:

$$RRDI_{jkt} = \frac{(R\&DStock/Value\ Added)_{jkt}}{(R\&DStock/Value\ Added)_{jUSt}} \tag{5.8}$$

where j, k and t index sector, country and time respectively, the numerator is the R&D intensity (RDI) in country k (i.e. one of the 27 non-US OECD countries) and the denominator is the RDI in the US. In line with our description of a leader and a laggard firm, we interpret an increase in $RRDI$ as an increase in the leadership (or equivalently, a decrease in the laggardship) of industry j in country k relative to the US.

[65] Many previous studies have used patent citations as an indicator of knowledge flows (Jaffe et al., 1993; Branstetter, 2006; Griffith et al., 2006). However, Gittelman and Alcácer (2006) demonstrate the substantial noise that is added through citations added by patent examiners, and the resulting biases in statistical inference and interpretation. Although we acknowledge this limitation in the data, we are not able to correct for citations added by patent-examiners since this information is only available from 2001 onwards.

[66] Of course, the fact that a firm applies for a US patent in which it builds on prior US knowledge from its home country does not necessarily mean that it is thus seeking technology through exports, as is the case in our theoretical model. It could for example also be benefitting from US knowledge through its interaction with US firms' subsidiaries present in its home country, or by using patent information which is available through the internet (cf. Branstetter, Fisman and Foley, 2006). Unfortunately, our lack of firm level data disables us to further explore this issue.

Similar to the $RRDI$ variable, we also compute labour productivity (defined as value added per hour worked) of the industries in the 27 (non-US) OECD countries relative to those in the US. This variable is denoted by RLP (relative labour productivity). In line with the firm-level specifications of our model, we interpret an increase in RLP as an increase in the productivity of industry j in country k relative to the US.[67]

Finally, in order to capture an asset or technology exploiting motive, we add a variable capturing the market size (defined as sectoral value added) of the industries in the 27 (non-US) OECD countries relative to those in the US as a control variable, denoted by RMS (relative market size).[68] A full list of sectors that are incorporated in the analysis is provided in Table A.1 in the Appendix.[69]

We then estimate the following probit model:

$$\begin{aligned} P(TSS_{ijkt} &= 1 | cit_{US,ijkt} \geq 1; rel\_cit_{US,ijkt} > 0) = \\ &\Phi(\beta_1 RRDI_{jkt} + \beta_2 RLP_{jkt} + \beta_3 RMS_{jkt} + D_j + D_t) + \varepsilon_{ijkt} \end{aligned} \tag{5.9}$$

where i indexes patent and Φ is the standard normal distribution. $RRDI$ measures relative RDIs as defined in (5.8), RLP measures relative labour productivity, RMS measures relative market size, and D_j, and D_t are sector and time dummies respectively. β_1 and β_2 are the parameters of interest. In line with our theoretical model, we expect that both $\beta_1 > 0$ and $\beta_2 > 0$. That is, if absorptive capacity or productivity of sector j in country k relative to the US increases – indicating a relative increase in leadership of sector j in country k relative to the US, according to our definition – we expect an increased probability of technology seeking FDI (i.e. from within the US). We further have a variance-covariance structure that allows for sectoral autocorrelation (given our panel data setup) and heteroscedasticity.

[67] Ideally, we should also include a proxy for relative technology transfer skills, but the OECD does not provide data that allow for such a proxy. However, in the regression analysis we include industry dummies to inter alia control for industry-specific differences in intra-firm technology transfer costs.

[68] Although we did not explicitly single out the effect of relative market size in our model, the inverse demand functions and profit functions in the Appendix make clear that a ceteris paribus increase in market size in country S relative to country N makes FDI by firm s less likely relative to exports, since fixed investment costs are less easily recouped.

[69] Even though all our variables include industry-level Value Added in their computation, the variation on R&D stocks and number of hours worked is sufficient to prevent issues of multicollinearity. Table A.2 in the Appendix gives descriptive statistics and pairwise correlations for the different subsamples.

Our final sample contains about 240,000 patents applied for by (and granted to) non-US firms over the period 1988-1999, where about 3,350 of those patents were applied for from within the US (i.e. for which the country of first inventor was the US).

Table 5.2 presents the estimation results of the model in (5.9). As we go from left to right in the table, we increase the restrictiveness of both cit_{US} and rel_cit_{US}, i.e. we increase the required extent of technology seeking by the patents in the sample.

Column (1) in the table does not impose any technology seeking requirements. As can be seen, the coefficient estimate for $RRDI$ is positive but not significant, whereas the coefficient on RLP is positive and highly significant. This indicates that without imposing any technology seeking requirements, firms in relatively more productive industries are more likely to locate their innovative activities in the US, which is consistent with the literature on the internationalization of R&D (Cantwell & Janne, 1999; Miller, 1995).

More important from the perspective of our model are the results in columns (2) through (10). From the table it follows that when increasing the technology seeking requirement, not only does the RRDI coefficient become significant, it also becomes larger in magnitude quite consistently when increasing rel_cit_{US} at each level of cit_{US}. This is illustrative of our model's outcome that absorptive capacity is an important driver of technology seeking through FDI. Second, the coefficient on RLP is also positive and significant, consistent with our model's prediction that high productivity is conducive to technology seeking through FDI. However, for very restrictive definitions of technology seeking ($rel\_cit_{US} \geq 0.5$), RLP becomes insignificant at each level of cit_{US}. This result, in combination with the significant effect of $RRDI$, illustrates the importance of absorptive capacity over productivity for technology seeking FDI, as captured by our extended definition of a laggard firm. Finally, the coefficient on RMS has the expected negative sign (*cf.* footnote 68).

These results should be considered as illustrative at the very most, since they are based on industry-level rather than firm-level leader and laggard characteristics. Nonetheless, they hint at the potential value of our theoretical model and its empirical implications. As such, they may provide a stepping-stone for future firm-level empirical analysis.

Also note that, although we have not explicitly focused on the technology or asset exploiting internationalization motive, it still is present in our analysis. For both the leader and the laggard also exploit their own technol-

Table 5.2: TS FDI and leadership at the industry level - Probit model estimates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
cit_{US}	none	≥ 1	≥ 1	≥ 1	≥ 2	≥ 2	≥ 2	≥ 3	≥ 3	≥ 3
rel_cit_{US}	none	$\geq 10\%$	$\geq 25\%$	$\geq 50\%$	$\geq 10\%$	$\geq 25\%$	$\geq 50\%$	$\geq 10\%$	$\geq 25\%$	$\geq 50\%$
$RRDI$ ($\times 100$)	0.002	0.004	0.006^{**}	0.008^{***}	0.007^{**}	0.009^{**}	0.011^{***}	0.008^{**}	0.009^{**}	0.011^{***}
	(1.04)	(1.44)	(2.14)	(2.61)	(2.06)	(2.55)	(2.95)	(1.96)	(2.21)	(2.62)
RLP ($\times 100$)	0.053^{***}	0.058^{***}	0.060^{***}	0.033	0.053^{***}	0.051^{***}	0.004	0.047^{**}	0.046^{**}	-0.032
	(4.90)	(3.92)	(3.46)	(0.94)	(3.23)	(3.08)	(0.18)	(2.38)	(2.33)	(-1.22)
RMS	-0.015^{***}	-0.017^{***}	-0.017^{***}	-0.017^{***}	-0.019^{***}	-0.018^{***}	-0.017^{***}	-0.020^{***}	-0.020^{***}	-0.017^{***}
	(-4.37)	(-3.83)	(-3.47)	(2.85)	(-3.54)	(-3.39)	(-2.88)	(-3.03)	(-2.99)	(-2.61)
sector dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
year dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
$P_{uc}(TSS=1)$	1.47%	1.82%	2.00%	2.41%	2.28%	2.34%	2.78%	2.86%	2.85%	3.14%
N	240,148	172,996	140,242	80,897	113,290	103,097	60,877	74,338	71,162	46,253
pseudo R^2	0.041	0.039	0.040	0.042	0.038	0.038	0.041	0.038	0.038	0.042

Notes: Dependent variable is Technology Seeking Strategy (TTS- 1/0). Z-statistics within parentheses, calculated on the basis of standard errors corrected for sectoral autocorrelation. Coefficients shown correspond to the marginal effects derived from the Probit model, they are multiplied by 100 to make them more comparable to the unconditional probability of sourcing FDI. Puc(TTS=1) denotes the unconditional probability of a patent to be made through seeking FDI (see definition in the main text). * p<0.1; ** p<0.05; ***p<0.01

ogy stocks through either exports or FDI, and eventually sell their products abroad. In fact, our analysis shows that for the laggard firm, the seeking motive of FDI is only of second-order importance (*cf.* Figure 5.3), since technology transfer skills from the parent to the subsidiary μ (which correspond the a technology exploiting motive) are a more important driver of FDI than those from the subsidiary to the parent λ. As indicated by Miller (1995) as well as some of the case examples discussed below, only after a minimum production scale has been achieved does technology seeking become interesting, feasible and viable. This means that rather than seeing technology exploitation and technology seeking as two distinct motives, they are naturally intertwined.

5.5 Productivity effects of TS FDI versus TE FDI

In the foregoing we have answered two out of the three questions that we set out to answer at the beginning of this chapter. First, we have asked why leaders instead of laggards appear to be engaging in TS FDI. The answer is that leaders seek technology through FDI, not mainly because they are just more productive than laggards, but because they have higher absorptive capacity and better intra-firm technology transfer skills. This better allows the entire firm to benefit from external knowledge, rather than just the foreign subsidiary. As shown by Cantwell and Janne (1999), the purpose of this type of FDI on behalf of leader firms is not primarily to catch-up, but rather to seek more diverse knowledge or technology. Indeed, following Kuemmerle (1999) and Le Bas and Sierra (2002), the term home-base-augmenting FDI may be more suitable in this regard. Second, we have asked what laggards are doing instead to catch up. The answer to this question is that laggards seek technology through exports, by learning from exporting. This technology seeking strategy requires less from the laggard firm in terms of intra-firm technology transfer skills, and therefore better fits its laggard nature.

In this section we will try and answer the third question: What does this imply for the productivity effects of TS FDI and TE FDI? As mentioned in the introduction of this chapter, Girma (2005) and Driffield and Love (2007) have already studied the extent to which these differing FDI motives generate different productivity effects in the UK. In both studies, the distinction between technology exploiting and seeking FDI is based on *inter alia* relative home-host RDIs. It is argued that since FDI with a technology seeking motive is aimed at seeking or sourcing technology in the host country which the MNE is lacking, it can reasonably be expected that the RDI of the home country-industry of the MNE is lower than that of the host country-industry. In other words, following the extant literature in this field, these studies also identify technology seeking as a motive for FDI by laggard firms. Hence, if the ratio of home country RDI over host country RDI is smaller than one, FDI is defined to be of the technology seeking type. If it is larger than one, it is termed technology exploiting FDI (*cf.* the discussion on (5.8) above).

Since TS FDI (by definition or assumption) originates from less R&D intensive industries than where it ends up – that is, since it is assumed to be undertaken by laggard firms – it is hypothesized that technology seeking FDI will not induce any knowledge diffusion. Technology exploiting FDI on the other hand is assumed to be undertaken by leader firms, and is thus expected to induce positive knowledge diffusion. Both Girma (2005) and Driffield and Love (2007) find broad support for these hypothesized effects.[70]

However, as we have demonstrated at length in the preceding analysis of this chapter, laggard firms are generally speaking not the ones engaging in FDI, regardless of the underlying motive. Following our analysis above, the relative RDIs used by Girma (2005) and Driffield and Love (2007) may be valid as indicators of leadership or laggardship, yet they cannot discriminate between TE FDI and TS FDI since our analysis shows that laggards generally engage in none of these strategies, whereas leaders tend to engage in both. Reasoning from this perspective, it is not at all obvious that TS FDI should generate smaller productivity effects on local firms than TE FDI. So indeed, we have yet to find an answer to the question what the differences in investment motives imply for the productivity effects of TS FDI and TE FDI.

In order to do so, we will use industry-level data of subsidiary activities of US MNEs in 13 OECD countries over the period 1987-2003 (*cf.* Table A.4 in the Appendix). We try to improve upon the analyses of Girma (2005) and Driffield and Love (2007) in distinguishing between the two investment

[70] The study by Driffield and Love (2007) also makes an additional distinction based on whether or not there is an efficiency seeking motive for FDI involved. Essentially, this efficiency seeking motive is expected to depress any positive diffusion effects of FDI because of the negative competition effects (based on lower host-country labor costs) it generates.

motives, by combining data on market orientation and two different proxies regarding subsidiary innovation. However, in order to compare our results to those of Girma (2005) and Driffield and Love (2007), we will also consider the relative RDIs between the US and the host countries and how it affects our empirical results. We elaborate on these contributions below.

5.5.1 FDI motives and market orientation

We use the same data as in Chapter 4 in order to measure the activities of foreign affiliates of US MNEs, i.e. industry-level data from the US Bureau of Economic Analysis (BEA) (*cf.* Section 4.3.1). As explained above, both Girma (2005) and Driffield and Love (2007) distinguish between technology seeking and exploiting FDI by comparing industry-level relative RDIs (RRDIs) between the home country (the US) and the host countries that US MNEs invest in. Specifically, they argue that FDI in industries with home-host RRDIs smaller than one corresponds to TS FDI, whereas FDI in industries with home-host RRDIs larger than one is of the TE type.

We expand on and alter this method in several ways. Specifically, we will use the market orientation of US MNEs' subsidiaries, together with proxies for their contribution to the innovative capabilities of the MNE, as a means to distinguish between the TE and TS motive. In doing so we draw from the literature on market seeking and efficiency seeking FDI (Markusen, 1984; Helpman, 1984; Markusen, 2002). Market seeking (or horizontal) FDI is aimed at generating sales in the host country market. Implicit therein is the exploitation of some firm specific (technology) asset or competitive advantage, since this is what gives the MNE an edge over its host country competitors and allows it to sell its products in foreign markets. As we already saw in Section 4.3.1, the BEA data allow us to distinguish the share of foreign affiliate sales of US MNEs destined for the local (host country) market. Following the above line of reasoning, we might use this share as a proxy for the extent of technology exploiting FDI of US MNEs' foreign affiliates. That is:

$$TE\ FDI = \frac{local\ sales_{jkt}}{total\ sales_{jkt}} \times FDI_{jkt} \tag{5.10}$$

where as before, j, k and t index industry, country and time respectively, and FDI is a measure of US MNE presence, proxied by the foreign affiliate capital stocks.

Next to this exploiting (or horizontal) type of FDI, we can also distinguish efficiency seeking (or vertical) FDI, which in general is aimed at globally splitting up the value chain and relocating the various activities to those places (countries) where they can be undertaken most efficiently, or where there are appropriate resources available (also see the model in Chapter 4). Similar to our approach in Section 4.3.1, we compute two variables to proxy parent seeking FDI (PS FDI) and other seeking FDI (OS FDI) as:

$$PS\ FDI = \frac{exports\ to\ US\ parent_{jkt}}{total\ sales_{jkt}} \times FDI_{jkt} \tag{5.11}$$
$$OS\ FDI = \frac{exports\ to\ third\ countries_{jkt}}{total\ sales_{jkt}} \times FDI_{jkt}$$

To see how these two proxies of efficiency seeking FDI can contribute to finding a proxy for TS FDI, note that both our home country (US) as well as our sample of host countries (OECD) are highly developed. Hence, the efficiencies or resources that US MNEs are seeking in this context may very well be related to technology (instead of the often mentioned low wages or natural resources). That is, in the present context our two measures of seeking FDI may (in many cases) very well be a proxy of technology seeking FDI. In order to illustrate this argument, consider Table 5.3. Column (1) shows the two measures of seeking FDI (PS and $OS\ FDI$) combined as a share of total FDI (PS and $OS\ FDI + TE\ FDI$) in each sector. The industries are ordered from high-tech (upper row) to low-tech (lower row), based on the OECD classification.[71]

What becomes clear immediately from the table is that the share of seeking FDI is close to (or sometimes even larger than) 50% of the total in high-tech and medium-tech industries, whereas in the low-tech industries TS FDI is clearly the minority type. The second and third column in Table 5.3 report $PS\ FDI$ and $OS\ FDI$ as a share of total FDI across industries. Although the relative shares of specifically $PS\ FDI$ are clearly the minority type, the overall inter-industry pattern in columns (2) and (3) is very similar to that in column (1). So indeed, this illustrates that both $PS\ FDI$ and $OS\ FDI$ might serve as proper proxies for TS FDI.

To further strengthen our use of these variables as proxies for TS FDI,

[71] The ordering of the industries in the table also corresponds to the median industry RDI from high (computers & electronic industries) to low (utilities). We choose the median RDI instead of the mean RDI because of some outliers in the distribution.

Table 5.3: Industry distribution of TS FDI (N=547)

Tech Intensity	Industry	(1) *Seeking FDI*	Of which: (2) *PS FDI*	(3) *OS FDI*
High Tech	Computers & electronics	0.47	0.08	0.40
Medium Tech	Chemicals	0.45	0.05	0.40
	Transportation equipment	0.45	0.09	0.36
	Electrical equipment, appliances & components	0.41	0.06	0.35
	Machinery	0.51	0.08	0.43
Low Tech	Primary & fabricated metals	0.37	0.03	0.33
	Food & kindred products	0.25	0.01	0.23
	Utilities	0.00	0.00	0.00

we complement them with two additional taxonomies.[72] First of all, utilizing subsidiary-level data on technology license payments received by foreign affiliates from their US parents, we are able to measure the extent to which a subsidiary is responsible for generating or creating new (to the firm as a whole) knowledge or technology. Specifically, if such payments are positive, we assume that a subsidiary has engaged in some degree of technology seeking activities. Hence, if these positive payments are combined with our measures of seeking FDI, we call it technology seeking FDI ($TS\ FDI$). If technology payments are zero but FDI is still of the seeking type, we consider it as more general efficiency seeking FDI. In the case of $TE\ FDI$, it is predominantly of the (technology) exploiting kind, regardless of the amount of technology license payments.

Second, following our discussion of Table 5.3, we also consider a distinc-

[72] Or, following Driffield and Love (2007) and the analysis in Chapter 4, it could be argued that the orientation of FDI is just related to the distinction between market-seeking and efficiency-seeking, and we need the additional characteristics discussed hereafter to separate the latter into efficiency seeking vis-à-vis technology seeking FDI.

tion between high and medium-tech sectors on the one hand, and low-tech sectors on the other hand in order to be able to relate the type of FDI to technology intensity (or similarly, to industries with high versus low RDIs, *cf.* footnote 71). Specifically, if the type of FDI is seeking FDI and takes place in high and medium tech industries, it will be predominantly of the technology seeking type, whereas if it occurs in low-tech industries, it will be searching for more general efficiencies. If the type is $TE\ FDI$, it will be predominantly (technology) exploiting FDI in all industry types.

In the light of the foregoing, we believe that our proxies for seeking FDI in combination with these taxonomies are preferable to those of Girma (2005) and Driffield and Love (2007), based on relative RDIs. However, in order to enhance comparability between our results and theirs, we also compute RRDIs in order to be able to apply their classification. RRDIs are calculated as:

$$RRDI_{jkt} = \frac{(MNE\_R\&DStock/MNE\_Capital\ Stock)_{jkt}}{(R\&DStock/Capital\ Stock)_{jkt}} \tag{5.12}$$

where j, k, and t index industry, country and time respectively. Hence, $RRDI$ is the ratio of the R&D intensity of US MNEs active in industry j, (host) country k and time t, over the R&D intensity of that host country's industry j at time t.[73] This improves upon Girma (2005) and Driffield and Love (2007), who use industry-level R&D intensities of the home country of the MNE as the numerator of $RRDI$. Following their line of argumentation, we classify both $TE\ FDI$ and *seeking FDI* with an $RRDI \geq 1$ (< 1) as technology exploiting FDI (technology seeking FDI). Table 5.4 summarizes this discussion, and presents the resulting taxonomy between technology exploiting and seeking FDI.

5.5.2 Variables and methodology

The model we wish to estimate is the same as that in Section 4.3.2 and takes the following form:

$$\omega_{jkt} = \beta_0 + \rho\omega_{jk,t-1} + \boldsymbol{\beta}_1\mathbf{FDI}_{jk,t-1} + \boldsymbol{\beta}_2\mathbf{X}_{jkt} + \eta_j + \nu_k + \upsilon_t + \varepsilon_{jkt} \tag{5.13}$$

[73] We use capital stocks rather than value added or output as the denominator in both RDIs (as we did in the previous section), since this is the only variable for which we have observations for both MNEs as well as industries.

Table 5.4: FDI taxonomies

Indicator		TE FDI	Seeking FDI
Technology license payments	> 0	Technology exploiting FDI	Technology seeking FDI
	$= 0$	Technology exploiting FDI	Efficiency seeking FDI
Industry classification	High& medium-tech	Technology exploiting FDI	Technology seeking FDI
	Low-tech	Technology exploiting FDI	Efficiency seeking FDI
Home-Host RDI	≥ 1	Technology exploiting FDI	Technology exploiting FDI
	< 1	Technology seeking FDI	Technology seeking FDI

where as before j, k and t index industry, country and time respectively, ω is total factor productivity (TFP), **FDI** is a vector with our different measures of TE and TS FDI in period $t-1$ to take into account the lag between MNE activity and productivity change (i.e. it takes time for FDI to have its full impact on productivity), $\mathbf{X}$ is a vector of control variables, η, ν and υ are fixed effects and ε is an idiosyncratic error term. We use two control variables in the vector $\mathbf{X}$: (the log of) industry-level exports, measured in millions of US dollars and also taken from the STAN database ($Exports$), and (the log of) industry-level R&D stocks, computed from data on R&D expenditures (from the OECD ANBERD database – $R\&D$) using the perpetual inventory method and imposing a generic annual depreciation rate of 15% (Hall and Mairesse, 1995).[74] Since industry-level exports also contain the exports of the US MNEs in our sample that we use in constructing the different FDI types, we net out those exports from the industry aggregate.

The FDI vector contains both $TE\ FDI$ and seeking FDI as defined above (below we enter both PS and $OS\ FDI$ combined as well as separately in the regression models). In order to do justice to the taxonomy as shown in Table 5.4, the model in (5.13) is not only analyzed for our total sample, but also

[74] Logs of these variables are used since their distributions are rather skewed, with a few industry-country pairs demonstrating very high levels of R&D stocks and exports.

for different subsamples that correspond to the different taxonomies implied by the rows in Table 5.4. Data on technology license payments and US MNE R&D stocks were also taken from the BEA and measured in millions of US dollars. R&D stocks were again computed from R&D expenditures, similar to the method for industry-level R&D.

As in Chapter 4, we first estimate industry-level Cobb-Douglas production functions to derive estimates of ω_{jkt}, and we again employ the system GMM estimator (Blundell and Bond, 1998) to estimate model (5.13). Since the dataset is similar as the one used in Chapter 4, the specifications of the GMM estimator are also the same, and the reader is referred to Section 4.3.2 for an elaborate discussion. The only crucial difference is that we restrict the lags used for instrumenting the endogenous variables ($\omega_{jk,t-1}$ and the FDI variables) to periods 4 and 5 when estimating model (5.13) for the different subsamples: in the subsamples, the number of observations is significantly reduced, so that using too many lagged realizations of the endogenous variables as instruments could result in overfitting of the model (Roodman, 2006).[75]

Table 5.5: Pairwise correlations (N=547)

	1.	2.	3.	4.	5.	6.	7.	8.
1. Log TFP	1.00							
2. Log lagged TFP	0.92	1.00						
3. Log R&D	0.19	0.19	1.00					
4. Log Exports	-0.06	-0.09	0.63	1.00				
5. TE FDI	-0.17	-0.13	0.32	0.19	1.00			
6. Seeking FDI[a]	0.19	0.14	0.20	0.11	-0.43	1.00		
7. PS FDI	0.22	0.19	-0.08	-0.16	0.00	0.34	1.00	
8. OS FDI	0.07	0.03	0.25	0.20	-0.45	0.83	-0.25	1.00
Mean	0.13	0.10	8.20	9.35	3.59	2.77	0.55	2.22
standard deviation	0.35	0.35	1.52	1.23	1.75	1.56	0.90	1.52

Notes: a) Seeking FDI is computed as PS FDI + OS FDI. Correlations $>|.08|$ are significant at $p<.05$.

[75] After restricting the analysis to the different subsamples, the error term in (5.13) only exhibits autocorrelation up to AR(3), so that realizations from the 4th lag onwards can be used as a valid instruments.

As mentioned above, our sample covers 13 OECD host countries and 8 manufacturing industries over the period 1987-2003 (*cf.* Table A.4 in the Appendix). However, the panel is very unbalanced due to missing observations for many countries. Moreover, data on technology license payments were only available from 1994 onward, so that those parts of the analyses utilizing this variable use a limited sample. Table 5.5 presents some summary statistics and correlations for the variables in our model. There is a relatively high correlation between R&D and exports (0.63). Even though we include both variables simultaneously in the empirical specifications below, running the regressions with either one of them did not change the results much. The high correlation between $seeking\ FDI$ and $OS\ FDI$ (0.83) is not problematic, since these two variables are never included in the model simultaneously.

5.5.3 Empirical results

Table 5.6 presents the results of the empirical model in (5.13), combined with the taxonomies proposed in Table 5.4. This table considers the combined effect of $PS\ FDI$ and $OS\ FDI$, depicted in the table as $seeking\ FDI$. The first column estimates the model for the full sample, the results of which correspond to column (1) in Table 4.2, except for the fact that the FDI coefficients are not standardized in this case. The coefficients of the control variables are all according to expectation, significant and sensible in magnitude. The coefficient on both $TE\ FDI$ and $seeking\ FDI$ are positive and significant, indicating positive productivity effects of both FDI types.

The bottom of the table provides the statistical tests of the models. The Sargan-Hansen test statistics of overidentifying restrictions are never significant, suggesting that the null hypothesis of valid (i.e. exogenous) instruments can be accepted. The AR statistics indicate first-order autocorrelation, as we would expect (given the inclusion of the lagged dependent variable), but no serial correlation from AR(4) or AR(5) onwards, confirming that our use of period 5-8 (or 4-5) lagged instruments is valid

However, given the taxonomies proposed in Table 5.4, $seeking\ FDI$ may now be capturing both technology seeking as well as more general efficiency seeking FDI. In order to make a more finely grained distinction between these two, the other columns in the table split up the sample in accordance with the classifications in Table 5.4.

Table 5.6: Productivity effects of TE and TS FDI

	(1) Total Sample	(2) Tech License Pay > 0	(3) Tech License Pay = 0	(4) High-Tech Industries	(5) Low-Tech industries	(6) RRDI ≥1	(7) RRDI<1
Lagged TFP	0.923*** (.028)	0.928*** (.034)	0.913*** (.024)	0.875*** (.045)	0.920*** (.046)	0.952*** (.027)	0.759*** (.102)
R&D Stock	0.030*** (.009)	0.031*** (.009)	0.024** (.012)	0.040*** (.012)	0.009 (.016)	0.015 (.009)	0.014 (.035)
Exports	0.021** (.008)	0.023** (.009)	0.006 (.020)	0.022 (.014)	0.013 (.018)	0.019* (.009)	0.050 (.050)
TE FDI^{a}	0.017** (.018)	0.019* (.011)	0.011 (.009)	0.010* (.005)	0.017 (.010)	0.002 (.007)	-0.016 (.016)
Seeking FDI^{a,b}	0.027*** (.009)	0.039*** (.001)	0.031*** (.008)	0.024** (.010)	0.034** (.013)	0.020** (.009)	0.000 (.018)
Constant	0.245** (.101)	0.050 (.097)	0.301*** (.111)	0.271*** (.073)	0.339** (.153)	0.055 (.075)	0.199* (.112)
Time Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-stat	125.9***	142.6***	316.8***	144.3***	1018.9***	233.5***	600.1***
AR(1)	-4.96***	-4.26***	-2.38**	-3.92***	-2.73***	-4.70***	-2.51***
AR(5) or AR(4)	-1.01	-1.40	-0.43	-1.43	-0.39	-1.74	-0.52
Sargan-Hansen test	40.2	29.2	27.1	15.7	14.8	26.2	6.3
N	547	176	104	376	171	324	122

Notes: a) 1-period lagged values of the variables are used; b) Seeking FDI is computed as PS FDI + OS FDI. Dependent variable is TFP. System GMM-estimates - One step robust estimator, lags 5-8 used for endogenous variables in column (1), and lags 4-5 in all other columns. * p<0.1; ** p<0.05; ***p<0.01.

Columns (2) and (3) in Table 5.6 split up the sample according to whether or not a foreign affiliate has received any technology license payments from the parent company. Column (2) considers those cases in which there were positive payments, whereas column (3) considers those where there were no payments whatsoever. The coefficient of $TE\ FDI$ is only significant in column (2), whereas *seeking* FDI has a positive and significant effect in both columns. This implies that both TS FDI and general efficiency seeking FDI generate positive productivity effects.

The taxonomy in columns (4) and (5) corroborates this finding. Here the sample is split up between high-tech and low-tech industries (high-tech including the high and medium-tech industries of Table 5.3). Again we find that in both samples, *seeking FDI* has a positive and significant productivity effect, whereas *TE FDI* is only positive and significant in the high-tech sample. Again these results imply that both TS FDI and general efficiency seeking FDI generate positive productivity effects.

Columns (6) and (7) split up the sample into those observations with a RRDI (from equation (5.12)) bigger and smaller than 1 respectively, in accordance with the approach undertaken by Girma (2005) and Driffield and Love (2007). As can be seen, *seeking FDI* is significant and positive only in column (6), indicating that only technology exploiting FDI yields positive productivity effects, according to the classification of Girma (2005) and Driffield and Love (2007).

Table 5.7 reruns the models of Table 5.6, now distinguishing between *PS FDI* and *OS FDI* For *TE FDI*, the general picture that emerges from Table 5.7 is that in all the subsamples, splitting up *seeking FDI* into *PS FDI* and *OS FDI* renders its effects insignificant (a result which is also somewhat familiar from Chapter 4).

For *PS FDI*, we observe a consistently positive and significant effect in all subsamples, whereas *OS FDI* is only positive and significant in those subsamples for which it proxies TS FDI (columns 2 and 4). Moreover, following the taxonomy of Girma (2005) and Driffield and Love (2007), column (7) shows that again none of the FDI types are positive and significant, implying that none of the TS FDI yields any significant productivity effects.

Table 5.7: Productivity effects of TE and TS FDI - Splitting up TS FDI

	(1) Total Sample	(2) Tech License Pay > 0	(3) Tech License Pay = 0	(4) High-Tech Industries	(5) Low-Tech industries	(6) RRDI ≥1	(7) RRDI<1
Lagged TFP	0.929*** (.028)	0.915*** (.031)	0.893*** (.080)	0.881*** (.044)	0.986*** (.035)	0.927*** (.028)	0.775*** (.087)
R&D Stock	0.031*** (.009)	0.027*** (.009)	0.026** (.012)	0.036*** (.010)	0.003 (.011)	0.022** (.011)	0.011 (.025)
Exports	0.019** (.009)	0.021*** (.008)	0.019 (.020)	0.019* (.010)	0.007 (.014)	0.022** (.008)	0.045 (.034)
TE FDI	0.018* (.010)	0.009 (.010)	0.005 (.010)	0.008 (.005)	0.014 (.019)	0.003 (.007)	-0.022 (.022)
PS FDI	0.029*** (.006)	0.042*** (.010)	0.143*** (.051)	0.028*** (.008)	0.023** (.009)	0.021*** (.007)	0.026 (.020)
OS FDI	0.031*** (.010)	0.028** (.011)	0.007 (.009)	0.022** (.009)	0.022 (.014)	0.016** (.013)	-0.006 (.014)
Constant	0.184* (.096)	0.084 (.097)	0.213** (.102)	0.274*** (.064)	0.022 (.128)	0.104 (.076)	0.269*** (.093)
Time Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-stat	153.6***	160.0***	103.6***	242.6***	676.7***	303.4***	362.0***
AR(1)	-5.05***	-4.31***	-2.62***	-3.93***	-2.50**	4.74***	-1.79**
AR(4) or AR(5)	-1.01	-1.37	-1.58	-1.42	-0.46	-1.02	-0.19
Hansen-test	49.2	24.0	26.9	19.4	17.4	19.8	18.0
N	547	176	104	376	171	324	109

Notes: a) 1-period lagged values of the variables are used. Dependent variable is TFP. System GMM-estimates - One step robust estimator, lags 5-8 used for endogenous variables in column (1), and lags 4-5 in all other columns. * p<0.1; ** p<0.05; ***p<0.01.

Taken together, applying our taxonomies these results demonstrate that both TS FDI and more general efficiency seeking FDI generate positive productivity effects (the latter result was also already clear from the analysis in the previous chapter). At the same time, applying the taxonomy of Girma (2005) and Driffield and Love (2007) we also find empirical results which are partly consistent with theirs. That is, we find that at least *PS FDI* and

OS FDI generate positive productivity effects with RRDI ≥ 1. However, as explained at length in the foregoing, this result should not come as a surprise since it essentially demonstrates that leaders (or firms from leading sectors) tend to generate productivity effects when they engage in FDI. But since we have argued that leaders can and will engage in both TE and TS FDI, such a taxonomy is not suited for distinguishing between these two FDI types.

Finally, we have checked the robustness of our results when using affiliate employment levels as the FDI proxy, instead of affiliate capital stocks (*cf.* Chapter 4). Similar to the analyses in Section 4.4, the results for *PS FDI* and *OS FDI* remained intact and comparable to those in Table 5.7, whereas the results of *TE FDI* we again largely absent, also in the total sample. In terms of the topic of this chapter, this means that the results regarding the productivity enhancing effects of TS FDI are robust to a change in the FDI proxy.

5.6 Conclusion

In this chapter, we set out to answer three interrelated questions: first, why are leaders and not laggards engaging in technology seeking FDI, as evidenced by real-world examples? Second, what are the laggards doing instead to compensate their lack of competitive assets or technology? And third, does this imply that technology seeking and technology exploiting FDI both lead to knowledge diffusion, even though recent econometric evidence begs to differ?

The first two questions we tackled by extending a simple model by Siotis (1999) to encompass both a broader definition of the leader-laggard distinction, as well as incorporating two alternative technology seeking strategies: FDI and exports. The answer to the first question is that leaders seek technology through FDI, not mainly because they are just more productive than laggards, but because they have higher absorptive capacity and better intra-firm technology transfer skills. This better allows the entire firm to benefit from external knowledge, rather than just the foreign subsidiary. As shown by Cantwell and Janne (1999), the purpose of this type of FDI on behalf of leader firms is not primarily to catch-up, but rather to seek more diverse knowledge or technology. Indeed, following Kuemmerle (1999) and Le Bas and Sierra (2002), the term home-base-augmenting FDI may be more suited in this regard.

The answer to the second question is that laggards – who are not only less productive than leaders, but also have lower absorptive capacity and are less skilled in transferring technology across firm units – seek technology through exports, by learning from exporting. This technology seeking strategy requires less from the laggard firm in terms of intra-firm technology transfer skills, and therefore better fits its laggard nature. Confronting these theoretical results with some case examples, recent econometric evidence and some preliminary exploratory industry-level analysis, we find broad overall support.

This led us to our third question: if (high-productivity) leader firms are engaging both in technology exploiting and technology seeking FDI, does this mean that technology seeking FDI also (next to technology exploiting FDI) induces knowledge diffusion effects? Using data on US MNEs' foreign activities in 13 OECD countries and 8 industries over the period 1987-2003, we are able to formulate an answer to our final question: both types of FDI generate positive productivity effects in their host economies, although the positive effects of TE FDI are not very robust to a change in the model specification.[76] These results are in stark contrast to the findings of Grünfeld (2005) and Driffield and Love (2007), who find that only technology exploiting FDI generates positive productivity effects. In light of the foregoing, we would argue that their methodology to distinguish these FDI types is not proxying investment motives, but rather (industry-level) leadership and laggardship.

Instead, in this chapter we have used the market-orientation of US MNEs' subsidiaries in combination with data on technology license payments, and high-tech versus medium and low-tech sectors to distinguish between technology seeking and exploiting FDI. Our results correspond well with the theoretical intuition developed in this chapter. As such, we believe these proxies to be more appropriate for inferring investment motives at the aggregate (industry) level.

[76] We also have to note that the number of observations for the different regressions in Section 5.5.3 is rather limited due to several sample restrictions, which could influence the results.

Appendix

Equilibrium profit functions

If both firms export:

$$\Pi_n^{ee} = \frac{(\alpha - 2c + c^* + a_n(2 - z\rho) + a_s(2\rho - 1))^2(S_N + S_S/t)}{9}$$

$$\Pi_s^{ee} = \frac{(\alpha + c - 2c^* + a_n(2z\rho - 1) + a_s(2 - \rho))^2(S_N/t + S_S)}{9}$$

If both firms engage in FDI:

$$\begin{aligned}\Pi_n^{ff} &= \frac{(\alpha - c + a_n(2 - z\phi) + a_s(2\phi\lambda_n - \mu_s))^2 S_N}{9} \\ &\quad + \frac{(\alpha - c^* + a_n(2\mu_n - z\phi\lambda_s) + a_s(2\phi - 1))^2 S_S}{9} - C^*\end{aligned}$$

$$\begin{aligned}\Pi_s^{ff} &= \frac{(\alpha - c + a_n(2z\phi - 1) + a_s(2\mu_s - \phi\lambda_n))^2 S_N}{9} \\ &\quad + \frac{(\alpha - c^* + a_n(2z\phi\lambda_s - \mu_n) + a_s(2 - \phi))^2 S_S}{9} - C\end{aligned}$$

If n exports and s engages in FDI:

$$\begin{aligned}\Pi_n^{ef} &= \frac{(\alpha - c + a_n(2 - z\phi) + a_s(2\rho - \mu_s))^2 S_N}{9} \\ &\quad + \frac{(\alpha - 2c + c^* + a_n(2 - z\phi\lambda_s) + a_s(2\rho - 1))^2 S_S}{9t}\end{aligned}$$

$$\begin{aligned}\Pi_s^{ef} &= \frac{(\alpha - c + a_n(2z\phi - 1) + a_s(2\mu_s - \rho))^2 S_N}{9} \\ &\quad + \frac{(\alpha + c - 2c^* + a_n(2z\phi\lambda_s - 1) + a_s(2 - \rho))^2 S_S}{9} - C\end{aligned}$$

If n engages in FDI and s exports:

$$\begin{aligned}\Pi_n^{fe} &= \frac{(\alpha - 2c + c^* + a_n(2 - z\rho) + a_s(2\phi\lambda_n - 1))^2 S_N}{9} \\ &\quad + \frac{(\alpha - c^* + a_n(2\mu_n - z\rho) + a_s(2\phi - 1))^2 S_S}{9} - C^*\end{aligned}$$

$$\Pi_s^{fe} = \frac{(\alpha + c - 2c^* + a_n(2z\rho - 1) + a_s(2 - \phi\lambda_n))^2 S_N}{9t} + \frac{(\alpha - c^* + a_n(2z\rho - \mu_n) + a_s(2 - \phi))^2 S_S}{9}$$

Derivation of dz/dt

First consider the effect of transport costs t on z_1:

$$\frac{dz_1}{dt} = \frac{[D_1 + (\rho + \Theta)(2 + \Theta)]\,(\alpha - c - 1)\partial\Theta/\partial t}{D_1^2}$$

where D_1 denotes the denominator in (5.6). Given our assumption of nonnegative profits (i.e. $(\alpha - c - 1) > 0$) and the fact that $\partial\Theta/\partial t < 0$, it follows that sign $dz_1/dt = -$ sign $[D_1 + (\rho + \Theta)(2 + \Theta)]$. Substituting D_1 yields sign $dz_1/dt = -$ sign $\left[2\mu_j + \phi(1 + 2\lambda_j) + \Theta^2\right] < 0$.

The effect of t on z_2 is given by:

$$\frac{dz_2}{dt} = \frac{[D_2 + (1 + \Theta)(4(\rho + 1) + \phi(\lambda_i + 1))]\,(2\alpha - 2c - \mu_i - 1)\partial\Theta/\partial t}{D_2^2}$$

where D_2 denotes the denominator in (5.7). Again, given our assumption of nonnegative profits (i.e. $(2\alpha - 2c - \mu_i - 1) > 0$) and the fact that $\partial\Theta/\partial t < 0$, it follows that sign $dz_2/dt = -$ sign $[D_2 + (1 + \Theta)(4 - \phi(\lambda_i + 1))]$. Substituting D_2 yields sign $dz_2/dt = -$ sign $\left[2\phi(1 + \lambda_j) + 2(\mu_j + 1) + 4(\rho + 1)\right] < 0$.

Table A.1: Countries and industries for Probit model

Countries	**Industries**
Austria	Agriculture
Australia	Mining and quarrying
Belgium	Food and drinks
Canada	Tobacco
Czech Republic	Textiles
Denmark	Clothing
Finland	Leather and footwear
France	Wood and products of wood and cork
Germany	Pulp, paper and paper products
Great Britain	Printing and publishing
Greece	Mineral oil refining, coke and nuclear fusion
Hungary	Chemicals
Ireland	Rubber and plastics
Israel	Non-metallic mineral products
Italy	Basic metals
Japan	Fabricated metal products
South Korea	Mechanical engineering
Luxemburg	Office machinery
Mexico	Manufacture of electrical machinery, n.e.c.
Netherlands	Radio, television and communication equipment
Norway	Manufacture of medical, precision and optical instruments
New Zealand	Motor vehicles
Poland	Railroad and transport equipment
Portugal	Miscellaneous manufacturing
Spain	Electricity and gas
Sweden	Construction
Switzerland	Business activities
Slovak Republic	Education

Table A.2: Descriptive statistics and pairwise correlations for Probit model

		Mean	St. Dev.	1	2	3	4
$cit_{US} \geq 1$	1. TSS	0.02	0.12	1.00			
	2. $RRDI$	1.42	7.50	0.00	1.00		
	3. RLP	1.21	2.98	0.00	-0.01	1.00	
	4. RMS	0.69	0.54	-0.04	-0.03	0.27	1.00
$cit_{US} \geq 2$	1. TSS	0.02	0.13	1.00			
	2. $RRDI$	1.41	7.16	0.00	1.00		
	3. RLP	1.23	3.30	0.00	-0.01	1.00	
	4. RMS	0.69	0.55	-0.04	-0.03	0.29	1.00
$cit_{US} \geq 3$	1. TSS	0.03	0.15	1.00			
	2. $RRDI$	1.39	6.86	0.01	1.00		
	3. RLP	1.27	3.60	0.00	-0.01	1.00	
	4. RMS	0.68	0.56	-0.03	-0.03	0.31	1.00

Table A.3: Countries and industries for GMM models

Countries	Industries
Belgium	Computers & electronic products
Canada	Chemicals
Denmark	Machinery
Finland	Electrical equipment, appliances & components
France	Transportation equipment
Germany	Food & kindred products
Ireland	Primary & fabricated metals
Italy	Utilities
Netherlands	
Norway	
Spain	
Sweden	
United Kingdom	

Chapter 6

Conclusion

This thesis has picked up a pressing issue in the FDI knowledge spillovers literature, which is the generally acknowledged ambiguity of the empirical evidence regarding the existence of such spillovers. The approach to this problem in the preceding chapters has been to consider the role of multinational heterogeneity in this ambiguity, by looking at differences in MNE ownership shares in their foreign subsidiaries (Chapter 3), dissimilarities in market orientations of MNEs' subsidiaries (Chapter 4), and heterogeneity in firm types and their consequent investment motives (Chapter 5). When possible and relevant, the analyses also considered vertical linkages as diffusion channels (Chapters 3 and 4), and previously ignored mediating factors such as Intellectual Property Rights Protection (Chapter 3) and Regional Integration Agreements (Chapter 4).

This concluding chapter will first briefly recapitulate the main outcomes and conclusions of the preceding chapters, followed by some policy implications and avenues for future research.

6.1 Taking stock

> "In the face of difficulties associated with capturing spillover effects and the multitude of factors that can influence the extent of spillovers in each economy, we caution researchers about drawing generalized conclusions about the existence of externalities associated with FDI [...]." (Javorcik and Spatareanu, 2005: p. 47)

Opening Chapter 2 with this quote, we start out by presenting a review of the theoretical and empirical literature on knowledge spillovers from FDI. Specifically, this chapter organizes the recent literature on this topic around three themes: Papers opening the black box of knowledge spillover mechanisms (Section 2.3), studies investigating mediating factors in the spillover process (Section 2.4), and finally, the literature on multinational heterogeneity (Section 2.5). We conclude that studies opening the black box are rather conclusive in their results, and confirm the existence of positive productivity effects of FDI. Studies on mediating factors and MNE heterogeneity on the other hand are less comparable due to *inter alia* differences in methodological approaches. Moreover, the literature on MNE heterogeneity seems to generate promising results, but there are still a number of aspects and different forms of heterogeneity that remain unexplored. This observation underlies the central theme of this thesis, which is the investigation of different dimensions of MNE heterogeneity, and their effects on knowledge diffusion from MNEs. Moreover, we also stress *inter alia* that researchers should make a more careful distinction between unintended knowledge spillovers (externalities) and intended knowledge transfers. We refer to the combination of these knowledge flows as knowledge diffusion.

Chapter 3 then begins by looking at differences in MNE ownership shares in their foreign subsidiaries, and its consequences for knowledge spillovers and diffusion. We first extend a model in New Trade Theory by Markusen and Venables (1999) to examine the intra-industry (horizontal) and inter-industry (vertical) effects of changes in MNE ownership over its foreign venture on local host-country firms, making an explicit distinction between horizontal knowledge spillovers, and vertical knowledge transfers. Although the total effects are somewhat ambiguous because of the opposing influences of price effects, (indirect) demand linkages, and knowledge diffusion (both spillovers and transfers), we use the moderating effect of Intellectual Property Rights Protection (IPP) to derive conditions under which some of these effects become unambiguously positive. Using a sample of 1,549 firms in 20 countries over the period 2000-2005, we find *inter alia* that (i) the degree of MNE ownership indeed influences the existence and extent of productivity effects, (ii) the relationship between MNE ownership and productivity effects depends on the direction of the effects (horizontal or vertical), (iii) productivity effects are larger in high IPP countries, indicating that MNEs are more willing to transfer knowledge vertically, which in turn may benefit intra-industry local firms through input and output linkages.

The literature on horizontal and vertical FDI (Helpman, 1984; Markusen, 1984; Markusen, 2002) suggests that market-orientation may also affect the existence and extent of knowledge diffusion from MNEs. This leads to an analysis of the effects of differences in market orientation of US MNEs on local industries in 13 OECD host-countries over the period 1987-2003 in Chapter 4. Extending a model of multinationals and endogenous growth to incorporate both horizontal (local market-oriented) and vertical (parent-oriented) FDI, we find that horizontal FDI is expected to generate larger productivity effects through knowledge diffusion than vertical FDI. The empirical results provide general support for this finding, although the estimated effect of horizontal FDI is somewhat sensitive to the exact measure used. Finally, since New Trade Theory suggests a mediating role of Regional Integration Agreements (RIAs) on these effects, we also compare the effects between the Canada United States Free Trade Agreement (CUSFTA) and the European Union (EU). Generally speaking, we find that the intra-industry productivity effects of horizontal and export platform FDI in the EU are larger than those in CUSFTA, whereas the reverse holds for vertical FDI.

An important aspect of the analyses in Chapters 3 and 4 is the assumption that MNEs (and consequently also their foreign ventures) are more productive than the local host-country firms that are affected by their investment, since this assumption gives rise to all the distinguished effects in the model. Yet the literature on firm heterogeneity and motives for FDI has argued with some credibility that also low-productivity (laggard) firms engage in FDI, not to exploit their (technological) firm-specific assets, but rather to seek or source such assets from foreign competitors by capturing knowledge spillovers.

We pick up this issue in Chapter 5, and illustrate – by means of some case examples – that not the laggard firms, but rather the (high-productivity) leader firms are the ones seeking (and exploiting) technology abroad through FDI. This in sharp contrast with some of the literature referred to above. We then pose three questions, which we pursue throughout the rest of the chapter: first, why are the leaders and not the laggards engaging in technology seeking FDI (TS FDI)? Using the insight that laggards are not only less productive than leaders (which would essentially only work to their advantage, as the relative gain from knowledge diffusion would be larger), but also have less absorptive capacity and lower intra-firm technology transfer skills, we find that laggards, as opposed to leaders, are simply not able to engage in FDI, regardless of the motive. That is, leaders engage in (TS) FDI because they can, whereas laggards cannot. Second, what are the laggards doing instead to compensate their lack of competitive assets or technology? Introducing exports as an alternative technology seeking strategy (linking to the learning by exporting literature), we find that this is the optimal strategy for laggards, as it requires no intra-firm technology transfer skills, and less absorptive capacity in order to be successful. These results are corroborated by case evidence, existing econometric evidence and novel industry-level analysis. And third, does this imply that TS FDI leads to knowledge diffusion after all? Using industry-level data of US MNEs' activities in 13 host-countries over the period 1987-2003, we find – in contrast to recent work by Girma (2005) and Driffield and Love (2007) – that TS FDI generates productivity effects, although we cannot solely describe these to knowledge diffusion.

In conclusion we can say that MNE heterogeneity indeed matters for the existence and extent of productivity effects in general, and knowledge diffusion in particular. However, it does so in different ways for different dimensions of heterogeneity. Regarding MNE ownership, there exist optimal and interior (i.e. between 0-100%) degrees of MNE ownership depending on the absence or presence of a well-developed IPP system. Not distinguishing along this dimension may generate biased results, in which conflicting effects due to differences in MNE ownership are lumped together in an averaged productivity effect. Further, although the superior productivity effect of horizontal over vertical FDI is mainly restricted to capital demonstration effects, we have also found that export-platform FDI generally yields very high productivity effects in the EU, thus potentially overstating the effects of the other two types when not properly distinguished empirically. Finally, the motive for FDI being either technology seeking or exploiting does matter somewhat for the existence of knowledge diffusion, as we have found that technology seeking FDI generally yields more consistent productivity effects than technology exploiting FDI. Hence, not accounting for these two different motives empirically may yield biased results.

6.2 Policy implications

Given the results of this thesis, what should policy makers do to maximize the benefits of multinational investment for their local economy? As indicated a number of times before, this should not be the primary question in this debate. Instead, we should first ask: is there a reason for government to act and intervene in the first place? That is, is there any kind of market failure which warrants government policy?

As explained in Chapters 1 and 2, a knowledge spillover indeed constitutes a failure of markets as it is an externality. However, much of the existing econometric analysis and evidence – including the analyses presented in the preceding chapters – is not able to separate the pure knowledge spillover from the price effects, competition effects, (indirect) demand linkage effects and knowledge transfer effects, most of them not externalities, and all of them together combined in the estimated total productivity effects of MNEs on local firms.

To illustrate this point, consider the estimated productivity effect of technology exploiting and seeking FDI in column 1 of Table 5.6 in Section 5.5.3. A one standard deviation increase in both FDI types in this sample induces an increase in industry TFP of approximately 7.2% ($[1.76 \times 0.017 + 1.56 \times 0.027]$). Taking the mean value of industry-level TFP in the sample (approximately $ US 1.13 mln), this implies an increase of approximately $ US 82,000 in industry TFP generated by local firms. However, as noted on several occasions in this thesis, this is a combined productivity effect, including not only knowledge spillovers but also price effects, competition effects, indirect demand linkages and possibly also knowledge transfer. Hence, the actual externality is in fact a fraction of this amount, but it is not straightforward to determine what fraction. Of course the analysis in Chapter 5 only considers MNE activity from the US, so that the productivity effects of *total* inward FDI of both types will be considerably larger. Yet still, comparing the dollar-value of these effects with the example given at the start of Chapter 1, where Renault was offered up to $ US 300 mln in direct subsidies alone in order to attract one of its subsidiaries into Brazil, it is clear that such amounts cannot be justified on basis of knowledge spillover benefits to productivity alone. Of course, policy makers and politicians are not solely led by economic reasoning, but also have to respond to political pressures and the lobby of interest groups in society at large. In this process, the most often heard argument for intervention is the potential for job creation or the prevention of job loss (in case multinationals decide to relocate part of their production elsewhere).[77] Depending on the number of jobs created or saved, the large

[77] Indeed, at the time of writing several newspapers regularly report on the presidential campaign in the US, with the democractic candidate Barack Obama having made several speeches, promising to bring back the jobs lost when American enterprises started to massively relocate production to Asia and South-America in the 1990s. In fact, the Barack Obama campaign has formulated explicit policy measures in this spirit, e.g. cutting tax

amounts of money spent on FDI policy are perhaps less striking, but since they do not correct externalities they are essentially unwarranted.

These objections notwithstanding, if governments and policymakers choose to engage in FDI-stimulating policies, the analyses in this thesis suggest some guidelines that would at least increase the validity of such policy and increase the probability of positive productivity effects through knowledge spillovers. Based on the results in Chapter 3, a first recommendation would be to make sure that a proper system of IPP is in place, as our theoretical and empirical results demonstrate that this stimulates both vertical and horizontal productivity effects. For vertical productivity effects, lower degrees of MNE ownership – and hence, a partnership between a MNE and a local firm – appear to be more appropriate, as the vertical linkages between the foreign venture and local upstream and downstream firms tend to decrease with MNE ownership. In general, since a large share of the horizontal effects also runs through indirect vertical linkages, supporting partnerships between local firms and MNEs seems a good strategy.[78]

Our analysis of the impact of affiliates' market orientation in Chapter 4 suggests that policymakers – especially in Canada – should primarily seek to ensure a minimum degree of inward vertical FDI, as this type of activity generates the most consistent and positive productivity benefits. Horizontal FDI also appears to generate positive effects, but mainly through capital demonstration effects. On the other end of the spectrum are the so-called export platforms, which according to our analysis mainly generate positive productivity effects in the EU.[79]

breaks for companies relocating jobs overseas, and rewarding companies who support American workers.

[78] Note that is not the same as saying that a government should impose a minimum of equity ownership by a local firm as an entry requirement, a policy measure that was often used in China and Eastern European countries (cf. Hoekman and Javorcik, 2005). Such a measure could create an incentive for the MNE to not transfer its propietary knowledge abroad, so that vertical (and horizontal) productivity effects cannot be realized. Instead of imposing such an arrangement, policy makers could use tax or subsidy instruments to keep the incentives in place while persuading the MNE to engage in a parternship with a local firm.

[79] This also puts the positive experiences of Ireland in a clear perspective, as it has managed – through the use of various incentive schemes – to attract a bulk of FDI and MNEs during the 1980s and 1990s. Many of these MNEs have used their Irish subsidiaries as gateways to continental Europe and the UK. That is, a large part of Irish FDI is of the export-platform type.

The results in Chapter 5 suggest that the investment motive of MNEs is also of some concern in order to ensure positive productivity effects, since technology seeking FDI generates more consistent positive productivity effects than technology exploiting FDI. This result also suggests avenues for more indirect policy measures, since they imply that investing in a knowledge-based economy, with high-quality workers, proper knowledge infrastructure and well-functioning industry-science linkages is also likely to attract MNEs that seek knowledge or technology abroad.

The results in this thesis also hint at some other possibilities for more indirect or moderating roles of government policy. We already mentioned the example of establishing a well-functioning system of IPP, in order to accommodate knowledge transfer. Additionally, parts of our analyses in Chapters 3 and 4 show that establishing vertical linkages between MNEs and local industries can be of prime importance in securing local productivity effects. As such, governments might also intervene through industry policy, solidifying inter-industry linkages or supporting intermediary agencies to bring together local suppliers and customers on the one hand, and MNEs on the other.

6.3 Avenues for future research

From an academic point of view, again a pressing issue is our inability to precisely pin-point the externality in the estimated productivity effects. Essentially, the methodology used in this thesis, combined with the type of data that are usually used in this type of analyses prevent us from doing so. As mentioned in Chapter 1, another strand of literature has used patent citations to track knowledge spillovers, similar to the methodology that we applied in Section 5.4.2. However, even a patent citation cannot be a measure of an unintended knowledge spillover. That is, when an inventor applies for a patent, he agrees to consciously transfer the knowledge to the public domain, for which he usually receives the monopoly right of commercialization of the invention for a period of time. This monopoly right allows the inventor to earn back (part of) the investment costs of his innovation, thus creating incentives for innovation. Alternatively, one can think of the monopoly right as (a future stream of) payments for knowledge the inventor has transferred to the public domain. As such, the knowledge and its subsequent use by others has been priced and paid for, and has consequently been internalized by the inventor.

Large scale econometric studies are not very likely to be able to resolve these issues, as the data – even at the firm or plant level – do not allow the researcher to separate the several effects leading up to a total productivity effect. Specifically, the knowledge transfer and knowledge spillover are hard – but crucial (from a policy perspective) – to separate. However, recent evidence from surveys (Javorcik, 2008) seems to be able to shed some more light on the issue, as the relevant agents within firms can indicate in which ways they have learned from foreign investors in their sectors, and which factors were important in the process. Indeed, more qualitative evidence – potentially also including in-depth multiple case studies – seems to be invaluable in order to complement the econometric studies. Not only can qualitative evidence lay bare the mechanisms that are important, it can also directly distinguish knowledge spillovers on the one hand from knowledge transfer, competitive effects, and indirect demand and supply linkages on the other hand. On top of that, it can directly shed light on the importance of mediating factors such as geography and absorptive capacity.

On the other hand, maybe the extreme focus on knowledge spillovers as the only externality in a host of other estimated effects is a bit too restrictive. As e.g. Blalock and Gertler (2008) and our analysis in Chapter 3 show, even knowledge transfer can induce unforeseen externalities via indirect vertical linkages and hence warrant government policy. From that perspective, estimating productivity effects may not be such an imperfect practice after all, and the studies in this thesis demonstrate the importance of accounting for (some forms of) multinational heterogeneity. However, as indicated in Chapter 2, any further progress (away from the inconclusive studies leading up to this thesis, and beyond the more detailed studies reviewed in Chapter 2 and undertaken in this thesis) is most likely to come from combining as many of these relevant aspects as possible. That is, we should start investigating whether the mediating effect of absorptive capacity and geography depend on the spillover channels considered, and whether or not this in turn depends on the market orientation of the MNE, which by itself may again be related to the extent of MNE ownership. Of course, the research questions and results become more complex in this case, but at least this will eventually better inform policy makers about relevant conditions and aspects under which different policy measures are most warranted. Already there are studies that are taking important steps in this direction (e.g. Wei and Liu, 2006; Liang, 2008).

Finally, what seems to be overlooked in this literature is the notion that a (tacit) knowledge spillover or transfer eventually, at the most basic level, takes place between two or more individuals. When looking at the different spillover channels, discussed in Section 2.3, it sometimes is easy to forget that eventually, people are involved in these mechanisms. As such, the study of knowledge spillovers and transfers, regardless of its context (FDI, trade, geography, etc.) is eventually a study of conscious or unconscious learning by one or more individuals from one or more others. An interesting future development can indeed take research to the level of individual agents and partly into the realm of psychology, where a lot of work on learning has already been done. Incorporating research on individual learning into the specific domain of MNEs could lead to interesting new insights.

Summary (in Dutch)

Dit proefschrift gaat over multinationals en de mate waarin investeringen van multinationals in het buitenland bijdragen aan productiviteitsontwikkeling van lokale bedrijven aldaar. Eén van de centrale aspecten in dit proces is de diffusie van kennis en technologie naar lokale bedrijven. Deze diffusie kan op verschillende manieren tot stand komen: in hun relaties met lokale afnemers en leveranciers kunnen de dochters van multinationals kennis over superieure producten of productietechnieken overbrengen. Daarnaast kunnen er demonstratie effecten optreden, doordat lokale bedrijven de meer geavanceerde producten, managementtechnieken of marketingstrategieën van multinationals gaan imiteren. Ook kan kennis over (productie)processen overgeheveld worden via personeeltransfers tussen de dochteronderneming van de multinational en lokale bedrijven.

Een belangrijk onderscheid in deze kennisdiffusie is dat tussen bedoelde en onbedoelde diffusie. Bedoelde kennisdiffusie treedt op wanneer een multinational bewust kennis overdraag naar bijvoorbeeld haar toeleveranciers. De prikkel om dit te doen bestaat dan waarschijnlijk uit het feit dat betere of kwalitatief hoogwaardigere *inputs* voor de multinational uiteindelijk ook de kwaliteit van haar eigen producten verbetert. Zodoende wordt deze bedoelde kennisoverdracht dan ook door de multinational geïnternaliseerd, dat wil zeggen, de multinational is in staat om hier een (impliciete) prijs aan te verbinden. Dit is niet het geval voor onbedoelde kennisdiffusie. Deze komt tot stand zonder dat de multinational dit heeft beoogd, bijvoorbeeld doordat lokale bedrijven in het buitenland producten van de dochteronderneming imiteren of kopiëren. Vanzelfsprekend heeft de multinational hier geen baat bij en zal ze zodoende wellicht besluiten om minder in kennisontwikkeling en innovatie te investeren, aangezien een deel van de beloning hiervoor kosteloos wegvloeit naar mogelijke concurrenten. Met andere woorden, onbedoelde kennisdiffusie wordt niet geïnternaliseerd en is daarom een externaliteit, ook

wel een kennisspillover genoemd.

Vanuit een economische oogpunt is dit onderscheid zeer relevant: daar waar een bedoelde kennisoverdracht (een kennistransfer genoemd) geen reden vormt tot overheidsingrijpen doet een kennisspillover dat wel. Immers, de kennisspillover kan ertoe leiden dat een multinational minder dan optimaal (vanuit een maatschappelijk oogpunt) investeert in kennis en innovatie, aangezien ze zich niet de volledige beloning hiervoor kan toe-eigenen. Hier ligt een rol voor de overheid om de kloof tussen het privaat rendement en het sociaal rendement van dergelijke investeringen te overbruggen, bijvoorbeeld door subsidies te verstrekken. Daarnaast vormen kennis en kennisspillovers de motor achter economische groei en ontwikkeling, waardoor het bestaan en ontstaan ervan ook vanuit dit oogpunt belangrijk is. Zodoende dient zich de vraag aan of de dochterondernemingen van multinationals – ook wel buitenlandse directe investeringen (BDI) genoemd – inderdaad leiden tot kennisspillovers en of de grote sommen geld die overheden vaak besteden om dergelijke investeringen aan te trekken (zie o.a. Hoofdstuk 1) wel geoorloofd zijn.

Naar deze vraag is veel onderzoek gedaan en Hoofdstuk 2 in dit proefschrift geeft een uitgebreid overzicht van voorgaande studies op dit gebied. Gedurende een lange tijd waren veel van deze studies niet erg consistent in hun resultaten: sommige onderzoeken vonden inderdaad bewijs voor het bestaan van kennisdiffusie van de dochterondernemingen van multinationals, terwijl andere studies geen bewijs vonden of zelfs negatieve effecten op de lokale economie documenteerden. Gedeeltelijk als een reactie op deze stand van zaken zijn meer recente studies op zoek gegaan naar meer gedetailleerde en genuanceerde aspecten binnen het kennisdiffusie proces. Globaal zijn hierbij drie stromingen te onderscheiden: op de eerste plaats zijn er in toenemende mate studies die één van de hierboven beschreven kanalen waarlangs kennis zich kan verspreiden individueel en expliciet analyseren (zie Sectie 2.3). Dit type onderzoek lijkt meer te convergeren naar het resultaat dat kennisdiffusie van BDI inderdaad plaatsvindt. Op de tweede plaats zijn er studies die kijken naar het effect van mediërende factoren zoals het belang van absorptiecapaciteit (de mate waarin lokale bedrijven in staat zijn om de weggelekte kennis daadwerkelijk te absorberen) of geografische afstand (zie Sectie 2.4). Hoewel het belang van geografische nabijheid voor het bestaan van kennisdiffusie in het algemeen wel is vastgesteld, geldt dit in mindere mate voor kennisdiffusie van BDI. Ook het belang van absorptiecapaciteit komt niet éénduidig naar voren. Ten derde is er een zeer recente literatuur die kijkt naar de heterogeniteit van multinationals en de mate waarin dit een effect heeft op kennisdiffusie van BDI (zie Sectie 2.5). Bij heterogeniteit valt bijvoorbeeld te denken aan verschillen in eigendomsstructuren in de dochterondernemingen, verschillen in investeringsmotieven of verschillen in moederlanden. Ook deze literatuur lijkt tot meer genuanceerde inzichten te leiden. Het feit dat er op het gebied van deze derde stroming nog relatief weinig onderzoek is gedaan maakt deze invalshoek dan ook bijzonder interessant en relevant voor verder onderzoek. De rest van dit proefschrift analyseert dan ook het effect van verschillende vormen van multinationale heterogeniteit op kennisdiffusie van BDI.

De eerste dimensie van multinationale heterogeniteit die in Hoofdstuk 3 aan de orde komt is het eigendomsaandeel van de moeder in haar buitenlandse dochter. Dit aandeel kan variëren tussen de 0% en 100% en de vraag die in dit hoofstuk wordt onderzocht is of verschillen hierin ook leiden tot verschillen in kennisdiffusie. De mogelijke verbanden worden eerst formeel theoretisch geanalyseerd, waarbij een onderscheid wordt gemaakt tussen verticale kennistransfers (kennisoverdracht van de dochteronderneming naar haar leveranciers en afnemers) en horizontale kennisspillovers (kennisoverdracht van de dochteronderneming naar haar concurrenten). Daarnaast worden ook andere effecten geanalyseerd, zoals effecten op de lokale vraag naar *inputs*, effecten op het lokale aanbod van *inputs* en effecten op de prijzen van lokale ondernemingen. Op basis van de theorie komen er geen eenduidige effecten naar voren van verschillen in eigendomsaandelen op kennisdiffusie. Desalniettemin kunnen er een aantal condities afgeleid worden waaronder het effect van een toenemend eigendomsaandeel positief is, mits er onderscheid wordt gemaakt tussen landen met een goed versus slecht functionerend systeem van intellectuele eigendomsrechten. Vervolgens worden de theoretische inzichten empirisch onderzocht in een panel van 1549 grote bedrijven in 20 landen over de periode 2000-2005. De resultaten wijzen op sterke niet-lineaire verbanden tussen het eigendomsaandeel van de multinational en verticale kennistransfers, waarbij er veelal een optimum tussen de 0% en 50% ligt. Voor horizontale kennisspillovers is het verband overwegend positief, hoewel dit wel conditioneel is op de kostenstructuur van de lokale ondernemingen: indien de variabele kosten een relatief hoog aandeel vormen in de totale kosten is de kans op positieve effecten groter. Tot slot lijken de totale effecten meer positief in landen met een goed functionerend systeem ter bescherming van het intellectuele eigendom dan in landen waar dit minder goed geregeld is.

In Hoofdstuk 4 analyseren we een tweede dimensie van multinationale heterogeniteit, te weten de marktoriëntatie van de dochteronderneming. Een impliciete veronderstelling in Hoofdstuk 3 was namelijk dat de dochter alleen voor de lokale markt produceert, maar in werkelijkheid zullen dochterondernemingen een (substantieel) deel van hun productie weer terug exporteren naar het moederland, of verder exporteren naar andere landen. Inzichten in de nieuwe handelstheorie laten zien dat dergelijke verschillen in marktoriëntatie gepaard gaan met verschillen in de organisatie en compositie van buitenlandse productie, wat op zijn beurt weer kan leiden tot verschillen in kennisdiffusie. Wederom worden deze relaties eerst formeel theoretisch onderzocht. Hieruit blijkt dat kennisdiffusie van dochters met een lokale marktoriëntatie (ook wel horizontale BDI genoemd) groter is dan van dochters die (een deel van) hun producten terug exporteren naar het moederland (ook wel verticale BDI genoemd). We testen deze verwachtingen empirisch met een dataset van de buitenlandse activiteiten van Amerikaanse multinationals gedurende de periode 1987-2003 op sector niveau. De empirische resultaten zijn inderdaad in overeenstemming met de theoretische verwachtingen, maar zijn relatief gevoelig voor veranderingen in de manier waarop buitenlandse activiteit gemeten wordt. Daarnaast blijkt dat het effect van dochters met een marktoriëntatie naar andere landen (ook wel export-platform BDI genoemd) positieve effecten heeft die significant groter zijn dan die van horizontale en verticale BDI. Onze dataset stelt ons verder in staat om deze effecten in twee verschillende economische regio's te bekijken: De Europese Unie (EU) en de *Canadian United States Free Trade Agreement* (CUSFTA). In overeenstemming met de theorie wijzen de empirische resultaten erop dat kennisdiffusie van horizontale BDI groter is in de EU dan in CUSFTA, terwijl het omgekeerde geldt voor verticale BDI. Het effect van export-platform BDI is enkel waarneembaar in de EU.

Zowel in Hoofdstuk 3 als in Hoofdstuk 4 is een andere impliciete veronderstelling steeds dat de multinational en haar dochter superieur zijn (in termen van kennis, productiviteit e.d.) aan de lokale ondernemingen in het gastland. Hoewel deze veronderstelling strookt met de algemeen bekende karakteristieken van multinationals, is er recentelijk een relatief grote literatuur ontstaan die beargumenteerd dat bedrijven met een lage productiviteit (zogenoemde achterblijvers) ook zullen investeren in het buitenland, om zo de kennis van hun meer geavanceerde buitenlandse concurrenten op te pikken. Het motief voor BDI is in dit geval het op zoek gaan naar buitenlandse kennis (kennis verwervende BDI), in plaats van het meer gangbare motief om de eigen kennis of het eigen concurrentievoordeel in het buitenland te exploiteren (kennis exploiterende BDI). Wanneer dit inderdaad het geval is zijn de veronderstelde kennisdiffusie effecten van kennis verwervende BDI lang niet zo aannemelijk als die van kennis exploiterende BDI. Hoofdstuk 5 onderzoekt deze relatie tussen investeringsmotieven en kennisdiffusie. Eerst wordt er aan de hand van een formeel theoretisch model onderzocht óf achterblijvers inderdaad willen profiteren van kennisdiffusie in het buitenland en zo ja, op welke manier ze dat zullen doen. De bevindingen wijzen uit dat ze dit inderdaad zullen proberen, maar eerder door te exporteren dan door het opzetten van een buitenlandse dochteronderneming. Integendeel, het zijn juist de bedrijven met een hoge productiviteit (de zogenoemde leiders) die via BDI zullen trachten om in het buitenland zowel kennis te exploiteren als kennis te verwerven. Anecdotisch en econometrisch bewijs bevestigen deze uitkomsten. Deze resultaten lijken er dan ook op te wijzen dat beide typen BDI zouden moeten leiden tot kennisdiffusie in het gastland. Gebruikmakend van dezelfde dataset als die in Hoofdstuk 4 wordt deze implicatie vervolgens getoetst: de empirische resultaten wijzen erop dat kennis verwervende BDI inderdaad ook leidt tot kennisdiffusie en dat de effecten vaak nog groter zijn dan die van kennis exploiterende BDI.

Concluderend kan gesteld worden dat dit proefschrift laat zien dat verschillende vormen van multinationale heterogeniteit inderdaad leiden tot verschillende productiviteitseffecten op lokale ondernemingen in het gastland, o.a. via kennisdiffusie. Daarbij maakt deze thesis nog een aantal andere contributies: op de eerste plaats is in de verschillende hoofdstukken het belangrijke onderscheid tussen kenisspillovers en kennistransfers aangehaald en is er daarnaast gewezen op het feit dat BDI naast deze kennisdiffusie effecten ook andere effecten op lokale ondernemingen teweeg zal brengen, bijvoorbeeld op het gebied van prijsinvloeden, concurrentie en als katalysator van toeleverende sectoren. Empirisch (of econometrisch) kunnen deze effecten lastig of niet uit elkaar gehaald worden, waardoor de beleidsimplicaties van de bevindingen in dit proefschrift met terughoudendheid moeten worden getrokken. Daarnaast heeft dit proefschrift expliciet het belang van een goed functionerend systeem ter bescherming van de intellectuele eigendom en verschillen tussen economische regio's voor de effecten van BDI aangetoond, waar dit in eerder onderzoek nog niet in deze mate is gebeurd.

List of acronyms

AC	Absorptive Capacity
AR	Autoregressive
BEA	Bureau of Economic Analysis
BT	British Telecom
BW	Backwardness
CES	Constant Elasticity of Substitution
CUSFTA	Canadian United States Free Trade Agreement
EU	European Union
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GM	General Motors
GMM	Generalized Method of Moments
(I)JV	(International) Joint Venture
IPP	Intellectual Property Rights Protection
ISIC	International Standard Industry Classification
IV	Instrumental Variable
LHS	Left Hand Side

JIT	Just In Time
MC	Marginal Costs
MNE	Multinational Enterprise
NBER	National Bureau of Economic Research
NUTS	Nomenclature of Territorial Units for Statistics
OECD	Organisation for Economic Cooperation and Development
PPP	Purchasing Power Parity
RDI	Research and Development Intensity
REI	Regional Economic Integration
RIA	Regional Integration Agreement
RRDI	Relative Research and Development Intensity
R&D	Research and Development
SIC	Standard Industry Classification
TE	Technology Exploiting
TFP	Total Factor Productivity
TS	Technology Seeking
UNCTAD	United Nations Conference on Trade and Development
US	United States
VTT	Vertical Technology Transfer
WOS	Wholly Owned Subsidiary

List of symbols

Chapter 3

α	input share of upstream products
β	marginal cost parameter
ε	elasticity of substitution between downstream varieties
F	fixed cost parameter
η	elasticity of demand for downstream products
I	total demand for intermediate products
n	number of firms
p	firm-level price
P	industry-level price index
Π	firm-level profits
ρ	MNE ownership share in IJV
σ	elasticity of substitution between upstream varieties
θ	strength of IPP protection
w	wages
x	output-level
Y	total income

Chapter 4

α	labor input coefficient in K	μ	manufacturing income share
β	marginal cost parameter	p	firm-level price
γ	FDI setup cost paramter	P	country-level price index
c	individual consumption	Π	firm-level profits
C	consumption index	r	interest rate
F	fixed cost parameter	ρ	subjective discount rate
ϕ	freeness of trade parameter	σ	elasticity of substitution
h	number of horizontal MNEs	τ	trade cost paramter
K	capital stock	v	number of vertical MNEs
L	labor	w	wages
λ	localization of spillovers	x	firm-level output
n	number of domestic firms	Y	total income
N	total number of firms	Z	numéraire good

Chapter 5

a	technology parameter	n	nothern firm
α	demand parameter	N	North
c	unit fixed cost	p	price
C	total fixed cost	Π	profits
e	export	q	output
f	FDI	ρ	export spillovers
ϕ	FDI spillover parameter	s	southern firm
h	marginal cost function	S	South
λ	subsidiary-parent technology transfer skill	t	transport cost
μ	parent-subsidiary technology transfer skill	z	technology gap

Bibliography

[1] Abraham, F., Konings, J. and Slootmaekers, V. (2007). FDI spillovers, firm heterogeneity and degree of ownership. Evidence from Chinese manufacturing. *CEPR Discussion Paper 6573*. Center for Economic Policy Research, London.

[2] Abramovitz, M. (1986). Catching up, forging ahead and falling behind. *Journal of Economic History* 46(2): 385-406.

[3] Acs, Z. and Audretsch, D. (1990). *Innovation and small firms.* MIT Press, Cambridge, MA.

[4] Aghion, P. and Howitt, P. (1997). *Endogenous growth theory*. MIT Press, Cambridge, MA.

[5] Aitken, B.J. and Harrison, A.E. (1999). Do domestic firms benefit from Direct Foreign Investment? Evidence from Venezuela. *The American Economic Review* 89(3): 605-618.

[6] Alcácer, J. and Gittelman, M. (2006). How do I know what you know? Patent examiners and the generation of patent citations. *Review of Economics and Statistics* 88(4): 774-779.

[7] Alfaro, L. and Rodríguez-Clare, A. (2004). Multinationals and linkages: An empirical investigation. *Economica* 4(2): 113-169.

[8] Almeida, P. (1996). Knowledge sourcing by foreign multinationals: Patent citation analysis in the U.S. semiconductor industry. *Strategic Management Journal* 17(Winter): 155-165.

[9] Almeida, P. and Kogut, B. (1999). Localization of knowledge and the mobility of engineers in regional networks. *Management Science* 45(7): 905-917.

[10] Almeida, P. and Phene, A. (2004). Subsidiaries and knowledge creation: The influence of the MNC and host country on innovation. *Strategic Management Journal* 25(8-9): 847-864.

[11] Allred, B.B. and Park, W.G. (2007). Patent rights and innovative activity: Evidence from national and firm-level data. *Journal of International Business Studies* 38: 878-900.

[12] Antras, P. and Helpman, E. (2004). Global sourcing. *Journal of Political Economy* 112(3): 552-580.

[13] Arnold, J. (2003). Productivity estimation at the plant level: A practical guide. *Mimeo*. Bocconi University, Milan

[14] Arrelano, M. and Bond, S. (1991). Some test of specification for panel data: Monte Carlo evidence and an application to employment equations. *Review of Economics and Statistics* 14: 328-352.

[15] Audretsch, D.B. and Feldman, M.P. (1996). R&D spillovers and the geography of innovation and production. *The American Economic Review* 86(3): 630-640.

[16] Baldwin, R., Braconier, H. and Forslid, R. (2005). Multinationals, endogenous growth and technological spillovers: Theory and evidence. *Review of International Economics* 13: 945-963.

[17] Baldwin, R., Martin, P. and Ottaviano, G. (2001). Global income divergence, trade and industrialization: The geography of growth take-off. *Journal of Economic Growth* 6: 5-37.

[18] Barba Navaretti, G. and Venables, A.J. (2004). *Multinational firms in the world economy*. Princeton University Press, Princeton, NJ.

[19] Barrios, S., Bertinelli, L. and Strobl, E. (2006). Coagglomeration and spillovers. *Regional Science and Urban Economics* 36: 467-481.

[20] Bartlett, C. and Ghoshal, S. (1989). *Managing across borders; the transnational solution*. Harard University Press, Cambridge MA.

[21] Baum, C.F. (2006). *An introduction to modern econometrics using Stata*. Stata Press, College Station TX.

[22] Berry, H. (2006). Leaders, Laggards, and the Pursuit of Foreign Knowledge. *Strategic Management Journal* 27: 151-168.

[23] Beugelsdijk, S., Hennart, J-F., Slangen, A. and Smeets, R. (2008). Why FDI misrepresents foreign MNE activity. *Mimeo*. University of Groningen, Groningen

[24] Beugelsdijk, S., Smeets, R. and Zwinkels, R. (2008). The impact of horizontal and vertical FDI on host's country economic growth. *International Business Review* 17(4): 452-472.

[25] Bitzer, J., Geishecker, I. and Görg, H. (2008). Productivity spillovers through vertical linkages: Evidence from 17 OECD countries. *Economics Letters* 99(2): 328-331.

[26] Bjorvatn, K. and Eckel, C. (2006). Technology sourcing and strategic Foreign Direct Investment. *Review of International Economics* 14(4): 600-614.

[27] Blalock, G. and Gertler, P.J. (2005). Foreign Direct Investment and externalities: The case for public intervention. In: Moran, T.H., Graham, E.M. and Blomström, M. (*eds.*). *Does Foreign Direct Investment promote development?* Institute for International Economics and Center for Global Development, Washington DC: 73-106.

[28] Blalock, G. and Gertler, P.J. (2008). Welfare gains from Foreign Direct Investment through technology transfer to local suppliers. *Journal of International Economics* 74(2): 402-421.

[29] Blomström, M. and Kokko, A. (1998). Multinational corporations and spillovers. *Journal of Economic Surveys* 12(2): 1-31.

[30] Blomström, M., Globerman, S. and Kokko, A. (2001). The determinants of host country spillovers from Foreign Direct Investment. In: Pain, N. (*ed.*). *Inward investment, technological change, and growth.* Palgrave, London: 34-65.

[31] Blomström, M. and Sjöholm, F. (1999). Technology transfer and spillovers: Does local participation with multinationals matter? *European Economic Review* 43(4-6): 915-923.

[32] Blundell, R. and Bond, S. (1998). Intitial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics* 87: 110-143.

[33] Bottazzi, L. and Peri, G. (2003). Innovation and spillovers in regions: Evidence from European patent data. *European Economic Review* 47: 687-710.

[34] Brainard, S.L. (1997). An empirical assessment of the proximity-concentration trafe-off between multinational sales and trade. *The American Economic Review* 87(4): 520-544.

[35] Branstetter, L. (2006). Is Foreign Direct Investment a channel of knowledge spillovers? Evidence from Japan's FDI in the United States. *Journal of International Economics* 68(2): 325-344.

[36] Branstetter, L., Fisman, R. and Foley, C.F. (2006). Do stronger intellectual property rights increase international technology transfer? Empirical evidence from US firm-level panel data. *The Quarterly Journal of Economics* 12(1): 321-349.

[37] Buckley, P.J. and Casson, M. (1981). The optimal timing of Foreign Direct Investment. *The Economic Journal* 91: 75-87.

[38] Buckley, P.S., Clegg, J., Forsans, N. and Reilly, K.T. (2003). Evolution of FDI in the United States in the context of trade liberalization and regionalization. *Journal of Business Research* 56: 853-857.

[39] Buckley, P.J., Clegg, J. and Wang, C. (2007*a*). Is the relationship between inward FDI and spillover effects linear? An empirical examination of the case of China. *Journal of International Business Studies* 38: 447-459.

[40] Buckley, P.J., Clegg, J. and Wang, C. (2007*b*), The impact of foreign ownership, local ownership and industry characteristics on spillover benefits from Foreign Direct Investment in China. *International Business Review* 16(2): 142-158.

[41] Bwalya, S.M. (2006). Foreign Direct Investment and technology spillovers: Evidence from panel data analysis of manufacturing firms in Zambia. *Journal of Development Economics* 81: 514-526.

[42] Cantwell, J.A. (1989). *Technological innovation and multinational corporations*. Basic Blackwell, Oxford UK.

[43] Cantwell, J.A. (1992). The effects of integration on the structure of multinational corporation activity in the EC. In: Klein, M.W. and Welfens, P.J.J. (*eds.*). *Multinationals in the new Europe and global trade*. Springer-Verlag, Heidelberg.

[44] Cantwell, J.A. and Janne, O. (1999). Technological Globalisation and Innovative Centres: The Role of Corporate Technological Leadership and Locational Hierarchy. *Research Policy* 28: 119-144.

[45] Cantwell, J.A. and Mudambi, R. (2005). MNE Competence-Creating Subsidiary Mandates. *Strategic Management Journal* 26: 1109-1128.

[46] Cantwell, J.A. and Smeets, R. (2008). FDI motives and host country productivity effects of US MNEs. *Mimeo*. Radboud University Nijmegen, Nijmegen.

[47] Carkovic, M. and Levine, R. (2005). Does Foreign Direct Investment accelerate economic growth? In: Moran, T.H., Graham, E.M. and Blomström, M. (*eds.*). *Does Foreign Direct Investment promote development?* Institute for International Economics and Center for Global Development, Washington DC: 195-220.

[48] Carr, D., Markusen, J.R. and Maskus, K.E. (2001). Estimating the knowledge capital model of the multinational enterprise. *The American Economic Review* 91: 693-708.

[49] Castellani, D. and Zanfei, A. (2003). Technology gaps, absorptive capacity and the impact of inward investments on productivity of European firms. *Economics of Innovation and New Technology* 12(6): 555-576.

[50] Castellani, D. and Zanfei, A. (2006). *Multinational firms, innovation and productivity*. Edward Elgar, Cheltenham UK

[51] Caves, R.E. (1974). Multinational firms, competition, and productivity host-country markets. *Economica* 41: 176-193.

[52] Charlton, A. (2003). Incentive bidding for mobile investment: Economic consequences and potential responses. *OECD Development Centre Working Paper 203*. OECD, Paris.

[53] Chen, T., Chen, H. and Ku, Y.H. (2004). Foreign direct investment and local linkages. *Journal of International Business Studies* 35: 320-333.

[54] Cheung, K. and Lin, P. (2004). Spillover effects of FDI on innovation in China: Evidence from the provincial data. *China Economic Review* 15: 25-44.

[55] Chung, W. and Alcácer, J. (2002). Knowledge Seeking and Location Choice of Foreign Direct Investment in the United States. *Management Science* 48(12): 1534-1554.

[56] Coe, E. and Helpman, E. (1995). International R&D spillovers. *European Economic Review* 39(5): 859-887.

[57] Cohen, W.S. and Klepper, S. (1996). Firm size and the nature of innovation within industries: The case of process and product R&D. *Review of Economics and Statistics*, 78(2): 232-243.

[58] Cohen, W. and Levinthal, D.A. (1989). Innovation and learning: The two faces of R&D. *The Economic Journal* 99(397): 569-596.

[59] Cohen, W. and Levinthal, D.A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly* 35(1): 128-152.

[60] Crespi, G., Criscuolo, C. and Haskel, J. (2006). Productivity, exporting and the learning-by-exporting hypothesis: Direct evidence from UK firms. *Queen Mary University of London Working Paper 559*. Queen Mary University, London.

[61] Dalton, D. and Serapio, M. (1991). US research facilities of foreign companies. U.S. Department of Commerce: Washington D.C.

[62] Davies, H. (1992). Some differences between licensed and internalized transfers of machine tool technology: An empirical note. *Managerial and Decision Economics* 13(6): 539-541

[63] D'aspremont, C. and Jacquemin, A. (1988). Cooperative and noncooperative R&D in duopoly with spillovers. *The American Economic Review* 78(5): 1133-1137.

[64] Dimelis, S. and Louri, H. (2002). Foreign ownership and production efficiency: A quantile regression analysis. *Oxford Economic Papers* 54(3): 449-469.

[65] Driffield, N. and Love, J.H. (2007). Linking FDI motivation and host economy productivity effects: Conceptual and empirical analysis. *Journal of International Business Studies* 38: 460-473.

[66] Dunning, J.H. (1977). Trade, Location of Economy Activity and MNE: A Search for an Eclectic Approach. In: Ohlin, B., Hesselborn, P.O. and Wijkman, P.S. (*eds.*). *The International Allocation of Economic Activity*. MacMillan, London: 395-418.

[67] Dunning, J.H. (*ed.)*(2000). *Regions, globalization and the knowledge-based economy*. Oxford University Press, Oxford UK.

[68] Dunning, J.H. and Narula, R. (1995). The R&D Activities of Foreign Firms in the United States. *International Studies of Management and Organization* 25(1-2): 39-73.

[69] Egan, M.L. and Mody, A. (1992). Buyer-seller links in export development. *World Development* 20(3): 321-334.

[70] Ekholm, K. and Forslid, R. (2001). Trade and location with horizontal and vertical multi-region firms. *Scandinavian Journal of Economics* 103: 101-118.

[71] Ekholm, K., Forslid, R. and Markusen, M. (2007). Export platform Foreign Direct Investment. *Journal of the European Economic Association* 5(4): 776-795.

[72] Falvey, R., Foster, N. and Greenaway, D. (2007). Relative backwardness, absorptive capacity and knowledge spillovers. *Economic Letters* 97(3): 230-234.

[73] Feinberg, S.E. and Gupta, A.K. (2004). Knowledge spillovers and the assignment of R&D responsibilities to foreign subsidiaries. *Strategic Management Journal* 25: 823-845.

[74] Feinberg, S.E. and Keane, M.P. (2005). Intra-firm trade of US MNCs: Findings and implications for models and policies towards trade and investment. In: Moran, T.H., Graham, E.M. and Blomström, M. (*eds.*). *Does Foreign Direct Investment promote development?* Institute for International Economics and Center for Global Development, Washington DC: 245-271.

[75] Feinberg, S.E. and Keane, M.P. (2006). Accounting for the growth of MNC based-trade using a structural model of US MNCs. *The American Economic Review* 96(5): 1515-1558.

[76] Feinberg, S.E. and Majumdar, S.K. (2001). Technology spillovers from Foreign Direct Investment in the Indian pharmaceutical industry. *Journal of International Business Studies* 32(3): 421-437.

[77] Findlay, R. (1978). Relative backwardness, Direct Foreign Investment, and the tranfsfer of technology: A simple dynamic model. *The Quarterly Journal of Economics* 92(1): 1-16.

[78] Florida, R. and Kenney, M. (1994). The globalization of Japanese R&D: The economic geography of Japanese R&D investment in the United States. *Economic Geography* 70(4): 305-323.

[79] Fors, G. (1997). Utilization of R&D results in the home and foreign plants of multinationals. *Journal of Industrial Economics* 45(3): 341-358.

[80] Fosfuri, A. and Motta, M. (1999). Multinationals without Advantages. *Scandinavian Journal of Economics* 101(4): 617-630.

[81] Fosfuri, A., Motta, M. and Ronde, T. (2001). Foreign Direct Investment and spillovers through workers' mobility. *Journal of International Economics* 53: 205-222.

[82] Frankel, J.A. and Romer, D. (1999). Does trade cause growth? *The American Economic Review* 89(3), 379-399.

[83] Frost, T.S. (2001). The Geographic Sources of Foreign Subsidiaries' Innovations. *Strategic Management Journal* 22(2): 101-123.

[84] Ginarte, J.C. and Park, W.G. (1997). Determinants of patent rights: A cross-national study. *Research Policy* 26(3): 283-301.

[85] Girma, S. (2005). Absorptive capacity and productivity spillovers from FDI: A threshold regression analysis. *Oxford Bulletin of Economics and Statistics* 67(3): 281-306.

[86] Girma, S. and Görg, H. (2007). The role of efficiency gap for spillovers from FDI: Evidence from the UK electronics and engineering sectors. *Open Economies Review* 18: 215-232.

[87] Girma, S., Görg, H. and Pisu, M. (2008). Exporting, linkages and productivity effects from Foreign Direct Investment. *Canadian Journal of Economics* 41(1): 320-40.

[88] Girma, S. and Wakelin, K. (2007). Local productivity spillovers from Foreign Direct Investment in the UK electronics industry. *Regional Science and Urban Economics* 37: 399-412.

[89] Glass, A.J. and Saggi, K. (1998). International technology transfer and the technology gap. *Journal of Development Economics* 55: 369-398.

[90] Glass, A.J. and Saggi, K. (2002). Intellectual property rights and Foreign Direct Invesment. *Journal of International Economics* 56: 387-410.

[91] Görg, H. and Greenaway, D. (2004). Much ado about nothing? Do domestic firms really benefit from Foreign Direct Investment? *World Bank Research Observer* 19(2): 171-197.

[92] Görg, H. and Strobl, E. (2001). Multinational companies and productivity spillovers: A meta-analysis. *The Economic Journal* 111(475): F723-F739

[93] Görg, H. and Strobl, E. (2005) Spillovers from foreign firms through worker mobility: An empirical investigation. *Scandinavian Journal of Economics* 107(4): 693-709.

[94] Griffith, R., Harrison, R. and Van Reenen, J. (2006). How special is the special relationship? Using the impact of US R&D spillovers on UK firms as a test of technology sourcing. *The American Economic Review* 96(5): 1859-1875.

[95] Griffith, R., Redding, S. and Simpson, H. (2002). Productivity convergence and foreign ownership at the establishment level. *Institute for Fiscal Studies Working Paper 22*. The institute for fiscal studies, London.

[96] Griffith, R., Redding, S. and Van Reenen, J. (2004). Mapping the two faces of R&D: Productivity growth in a panel of OECD industries. *Review of Economics and Statistics* 86(4): 883-895.

[97] Griliches, Z. (1979). Issues in assesing the contribution of R&D to productivity growth. *Bell Journal of Economics* 10: 92-116.

[98] Grossman, G. and Helpman, E. (1991). *Innovation and growth in the global economy*. MIT Press, Cambridge MA.

[99] Grünfeld, L. (2006). Multinational production, absorptive capacity, and endogenous R&D spillovers. *Review of International Economics* 14(5): 922-940.

[100] Hagedoorn, J., Cloodt, D. and Kranenburg, H. van. (2005). Intellectual property rights and the governance of international R&D partnerships. *Journal of International Business Studies* 36(2): 175-186.

[101] Hagedoorn, J. and Hese, G. (2007). Contract-law and the governance of inter-firm technology partnetships. An analysis of different forms of partnering and their contractual implications. *Journal of Management Studies* 44: 342-366.

[102] Hale, G. and Long, C. (2006). What determines technological spillovers of Foreign Direct Investment? Evidence from China. *Yale Economic Growth Center Discussion Paper 934*. Yale University, New Haven NE.

[103] Hall, B.H. and Mairesse, J. (1995). Exploring the relationship between RD and productivity and French manufacturing firms. *Journal of Econometrics* 65(1): 253-203.

[104] Hansen, M.T. and Birkinshaw, J. (2007). The innovation value chain. *Harvard Business Review* June: 1-14.

[105] Helpman, E. (1984). A simple theory of international trade with multinational corporations. *Journal of Political Economy* 92(3): 451-471.

[106] Helpman, E., Melitz, M. and Yeaple, S. (2004). Export versus FDI with heterogeneous firms. *The American Economic Review* 94(1): 300-316.

[107] Hennart, J.F. and Park, Y.R. (1993). Greenfield vs. Acquisition: The Strategy of Japanese Investors in the United States. *Management Science* 39(9): 1054-1070.

[108] Heston, A., Summers, R. and Aten, B. (2006). *Penn World Tables version 6.2*. Center for international comparison of production, income and prices: University of Pennsylvania.

[109] Hobday, M. (1996). *Innovation in East Asia. The challenge to Japan*. Edward-Elgar, Cheltenham UK.

[110] Hoekman, B. and Javorcik, B.S. (2006). Lessons from empirical research on international technology diffusion through trade and Foreign Direct Investment. In: Hoekman, B. and Javorcik, B.S. (*eds.*). *Global integration and technology transfer*, Palgrave MacMillan/The World Bank, Washington DC: 1-26.

[111] Holm, U., Malmberg, A. and Solvell, O. (2003). Subsidiary impact on host country economies – the case of foreign owned subsidiaries attracting investment into Sweden. *Journal of Economic Geography* 3: 389-408.

[112] Hymer, S.H. (1960). *The International Operations of National Firms: A Study of Direct Foreign Investment*. Ph.D. dissertation, MIT, Cambridge MA.

[113] Jaffe, A.B. and Trajtenberg, M. (2002). *Patents, citations & innovations. A window on the knowledge economy*. MIT Press, Cambridge MA.

[114] Jaffe, A.B., Trajtenberg, M. and Henderson, R. (1993). Geographic localization of knowledge spillovers as evidenced by patent citations. *The Quarterly Journal of Economics* 108(3): 577-598.

[115] Javorcik, B.S. (2004*a*). Does Foreign Direct Investment increase the productivity of domestic firms? In search of spillovers through backward linkages. *The American Economic Review* 94(3): 605-627.

[116] Javorcik, B.S. (2004*b*). The composition of Foreign Direct Investment and protection of intellectual property rights: Evidence from transition countries. *European Economic Review* 48: 39-62.

[117] Javorcik, B.S. (2008). Can survey evidence shed light on spillovers from Foreign Direct Investment? *World Bank Research Observer* 23(2): 139-159.

[118] Javorcik, B.S., Saggi, K. and Spatareanu, M. (2004). Does it matter where you come from? Vertical spillovers from Foreign Direct Investment and the nationality of investors. *World Bank Policy Research Working Paper 3449*. World Bank, Washington DC.

[119] Javorcik, B.S. and Spatareanu, M. (2005). Disentangling FDI spillover effects: What do firm perceptions tell us? In: Moran, T.H., Graham, E.M. and Blomström, M. (*eds.*), *Does Foreign Direct Investment promote development?* Institute for International Economics and Center for Global Development, Washington DC: 45-71.

[120] Javorcik, B.S. and Spatareanu, M. (2008). To share or not to share: Does local participation matter for spillovers from Foreign Direct Investment? *Journal of Development Economics* 85(1-2): 194-217.

[121] Jong, E. de and Semenov, R. (2006). Cultural determinants of ownership concentration across countries. *International Journal of Business Governance and Ethics* 2: 145-165.

[122] Kafouros, M.I. and Buckley, P.J. (2008). Under what conditions do firms benefit from the research efforts of other organizations? *Research Policy* 37(2): 225-239.

[123] Kathuria, V. (2002). Liberalisation, FDI and productivity spillovers. An analysis of Indian manufacturing firms. *Oxford Economic Papers* 54: 688-718.

[124] Keane, M.P. and Feinberg, S.E. (2007). Advances in logistics and the growth of intra-firm trade: The case of Canadian affiliates of US multinationals, 1984-1995. *Journal of Industrial Economics* 65(4): 571-631.

[125] Keller, W. (2002). Geographic localization of international technology diffusion. *The American Economic Review* 92(1): 120-142.

[126] Keller, W. (2004). International technology diffusion. *Journal of Economic Literature* 52: 752-782.

[127] Kim, L. (1997). *Immitation to innovation. The dynamics of Korea's technological learning.* Harvard Business School Press, Boston MA.

[128] Koeswaman (1995). *Textile export marketing and technology acquisition efforts in the Indonesian textile industry.* PhD dissertation, University of Twente, The Netherlands.

[129] Kogut, B. and Chang, S.J. (1991). Technological Capabilities and Japanese Foreign Direct Investment in the United States. *Review of Economics and Statistics* 73(3): 401-413.

[130] Kokko, A. (1994). Technology, market characterstics and spillovers. *Journal of Development Economics* 43: 279-293.

[131] Krugman, P. 1991. Increasing returns and economic geography. *Journal of Political Economy* 99: 483-499.

[132] Kuemmerle, W. (1999). Foreign Direct Investment in Industrial Research in the Pharmaceutical and Electronics Industries - Results from a Survey of Multinational Firms. *Research Policy* 28(2-3): 179-193.

[133] Kugler, M. (2006). Spillovers from Foreign Direct Investment: Within or between industries? *Journal of Development Economics* 80: 444-477.

[134] Lall, S. (1980). Vertical interfirm linkages in LDCs: An empirical study. *Oxford Bulletin of Economics and Statistics* 42: 203-226.

[135] Le Bas, C. and Sierra, C. (2002). Location versus Home Country Advantages in R&D Activities: Some further Results on Mulnationals' Location Strategies. *Research Policy* 31(4): 589-609.

[136] Levinsohn, J. and Petrin, A. (2003). Estimating production functions using inputs to control for unobservables. *Review of Economic Studies* 70(2): 317-341.

[137] Liang, H. (2008). Does Foreign Direct Investment improve the productivity of domestic firms? Technology spillovers, industry linkages

and firm capabilities. *Mimeo*. Haas School of Business, University of California at Berkeley.

[138] Lin, P. and Saggi, K. (2005). Multinational firms and backward linkages: A critical survey and a simple model. In: Moran, T.H., Graham, E.M. and Blomström, M. (*eds.*). *Does Foreign Direct Investment promote development?* Institute for International Economics and Center for Global Development, Washington DC: 159-174.

[139] Lin, P. and Saggi, K. (2007). Multinational firms, exclusivity and backward linkages. *Journal of International Economics* 71: 206-220.

[140] Lipsey, R.E. (2001). Foreign Direct Investment and the operations of multinational firms: Concepts, history and data. *NBER Working Paper 8665*. Cambridge MA.

[141] Lipsey, R.E. and Sjöholm, F. (2005). The impact of inward FDI on host countries: Why such different answers? In: Moran, T.H., Graham, E.M. and Blomström, M. (*eds.*), *Does Foreign Direct Investment promote development?* Institute for International Economics and Center for Global Development, Washington DC: 23-43.

[142] Liu, X., Wang, C. and Wei, Y. (2006). Trade orientation and mutual productivity spillovers between local and foreign firms in China. *Journal of Asia Business Studies* 1(1): 46-53.

[143] Lokshin, M. (2006). Difference-based semiparametric estimation of partial linear regression models. *The Stata Journal* 6(3): 377-383.

[144] Madariaga, N. and Poncet, S. (2007). FDI in Chinese cities: Spillovers and impact on growth. *World Economy* 30(5): 837-862.

[145] Marin, A. and Bell, M. (2006). Technology spillovers from Foreign Direct Investment (FDI): The active role of MNC subsidiaries in Argentina in the 1990s. *Journal of Development Studies* 42(4): 678-697.

[146] Markusen, J.R. (1984). Multinationals, multi-plant economies and the gains from trade. *Journal of International Economics* 16: 205-226.

[147] Markusen, J.R. (2001). Contracts, intellectual property rights, and multinational investment in developing countries. *Journal of International Economics* 53: 189-204.

[148] Markusen, J.R. (2002). *Multinational Firms and the Theory of International Trade*. MIT Press, Cambridge MA.

[149] Markusen, J.R. and Trofimenko, N. (2009). Teaching locals new tricks: Foreign experts as a channel of knowledge transfer. *Journal of Development Economics* 88(1): 120-131.

[150] Markusen, J.R. and Venables, A.J. (1999). Foreign Direct Investment as a catalyst for industrial development. *European Economic Review* 43: 335-356.

[151] Martin, P. and Ottaviano, G. (1999). Growing locations: Industry location in a model of endogenous growth. *European Economic Review* 43: 281-302.

[152] Melitz, M. (2003). The impact of trade on aggregrate industry productivity and intra-industry reallocations. *Econometrica* 71(6): 1595-1725.

[153] Miller, R. (1992). Global R&D networks and large-scale innovations: The case of the automobile industry. *Research Policy* 23: 27-46.

[154] Minbaeva, D., Pedersen, T., Björkman, I., Fey, C.F. and Park, H.J. (2003). MNC knowledge transfer, subsidiary absorptive capacity, and HRM. *Journal of International Business Studies* 34(6): 586-599.

[155] Monteiro, F. and Sull, D. (2006). BT group: Bringing external innovation inside. *London Business School Case: CS-07-005*. London Business School, London.

[156] Moran, T.H., Graham, E.M. and Blomström (*eds.*) (2005). *Does Foreign Direct Investment promote development?* Institute for International Economics and Center for Global Development, Washington DC.

[157] Motta, M. (1996). Multinationals without advantages. *IUI Working Paper 464*. Research Institute of Industrial Economics, Sweden.

[158] Mudambi, R. and Navarra, P. (2004). Is knowledge power? Knowledge flows, subsidiary power and rent-seeking within MNCs. *Journal of International Business Studies* 35(5): 385-406.

[159] Müller, T. and Schnitzer, M. (2006). Technology transfer and spillovers in international joint ventures. *Journal of International Economics* 68(2): 456-468.

[160] Neven, D. and Siotis, G. (1996). Technology Sourcing and FDI in the EC: An Empirical Evaluation. *International Journal of Industrial Organization* 14(5): 543-560.

[161] Nicolini, M. and Resmini, L. (2007). Productivity spillovers and multinational enterprises: In search of a spatial dimension. *DYNREG Working Paper No. 10* - The Economic and Social Research Institute, Dublin.

[162] Nunn, N. and Trefler, D. (2008). The boundaries of the multinational firm: An empirical analysis. In: Helpman, E. and Marin, D. (*eds.*). *Globalization and the Organization of Firms and Markets*. Harvard University Press: Cambridge, MA: forthcoming.

[163] OECD (2007). *Business Enterprise Research and Development Database*. OECD, Paris.

[164] Olley, S.G. and Pakes, A. (1996). The dynamics or productivity in the telecommunications equipment industry. *Econometrica* 64(6): 1263-1297.

[165] Pack, H. and Saggi, K. (2001). Vertical technology transfer via international outsourcing. *Journal of Development Economics* 65(2): 389-415.

[166] Peri, G. and Urban, D. (2006). Catching-up to foreign technology? Evidence on the "Veblen-Gerschenkron" effect of foreign investments. *Regional Science and Urban Economics* 36: 72-98.

[167] Phene, A. and Almeida, P. (2008). Innovation in multinational subsidiaries. The role of knowledge assimilation and subsidiary capabilities. *Journal of International Business Studies* 39(5): 901-919.

[168] Poole, J.P. (2008). Multinational spillovers through worker turnover. *Mimeo*. University of California, Santa Cruz.

[169] Prahalad, C.K. and Doz, L. (1987). *The multinational mission*. Free Press, New York.

[170] Rodríguez-Clare, A. 1996. Multinationals, linkages and economic development. *The American Economic Review* 86(4): 852-873.

[171] Romer, P. (1990). Endogenous technological change. *Journal of Political Economy* 98(5): S71-S102.

[172] Roodman, D. (2006). How to do xtabond2: An introduction to "difference" and "system" GMM in Stata. *Center for Global Development Working Paper 103*, Washington DC.

[173] Rugman, A.M. (1981). *Inside the multinationals: The economics of internal marktets*. Columbia University Press: New York.

[174] Saggi, K. (2002). Trade, Foreign Direct Investment, and international technology transfer: A survey. *World Bank Research Observer* 17(2): 191-235.

[175] Saggi, K. (2006). Foreign Direct Investment, linkages and technology spillovers. In: Hoekman, B. and Javorcik, B.S. (*eds.*). *Global integration and technology transfer*. Palgrave MacMillan/The World Bank, Washington DC: 51-65.

[176] Sanna-Randaccio, F. and Veugelers, R. (2007). Multinational knowledge spillovers with decentralised R&D: A game-theoretic approach. *Journal of International Business Studies* 38(1): 47-63.

[177] Salomon, R. and Jin, B. (2008). Does knowledge spill to leaders or laggards? Exploring industry heterogeneity in learning by exporting. *Journal of International Business Studies* 39(1): 132-150.

[178] Schoors, L. and Van der Tol, B. (2002). Foreign Direct Investment spillovers within and between sectors: Evidence from Hungarian data. *Universiteit Gent Working Paper 157*. University of Gent, Gent.

[179] Shan, W. and Song, J. (1997). Foreign Direct Investment and the Sourcing of Technological Advantage: Evidence from the Biotechnology Industry. *Journal of International Business Studies* 28(2): 267-284.

[180] Singer, H. (1950). The distribution of gains between investing and borrowing countries. *The American Economic Review Papers and Proceedings* 40: 573-585.

[181] Singh, J. (2007). Assymetry of knowledge spillovers between MNC and host country firms. *Journal of International Business Studies* 38(5): 764-786.

[182] Siotis, G. (1999). Foreign Direct Investment Strategies and Firms' Capabilities. *Journal of Economics & Management Strategy* 8(2): 251-270.

[183] Smeets, R. (2008). Collecting the pieces of the FDI knowledge spillovers puzzle. *World Bank Research Observer* 23(2): 107-138.

[184] Smeets, R. and Bosker, E.M. (2008). Firm heterogeneity and technology seeking strategies. *Academy of International Business Best Paper Proceedings 2008 - 0127.*

[185] Smeets, R. and De Vaal, A. (2008). Multinational ownership, intellectual property rights and knowledge diffusion from FDI. *Nijmegen Center for Economics Working Paper 08-110.*

[186] Smeets, R. and Wei, Y. (2009). Productivity effects from US MNEs: The roles of market orientation and regional integration. *Regional Studies*, forthcoming.

[187] Tavares, A.T. and Young, S. (2006). Sourcing patterns of foreign-owned multinational subsidiaries in Europe. *Regional Studies* 40(6): 583-599.

[188] UNCTAD (2003). *World Investment Report 2003. FDI policies for development: National and international perspectives.* United Nations

[189] UNCTAD (2004). *Incentives. UNCTAD series on inssues in international investment agreements.* United Nations, Geneva, Switzerland.

[190] Wei, Y. and Liu, X. (2006). Productivity spillovers from R&D, exports and FDI in China's manufacturing sector. *Journal of International Business Studies* 37: 544-557.

[191] Wei, Y., Liu, X. and Wang, C. (2008). Mutual productivity spillovers between local and foreign firms in China. *Cambridge Journal of Economics* 32(4): 609-631.

[192] Wang, J-Y. and Blomström, M. (1992). Foreign investment and technology transfer. A simple model. *European Economic Review* 36: 137-155.

[193] Yang, Q., Mudambi, R. and Meyer, K. (2008). Conventional and reverse knowledge flows in multinational corporations. *Journal of Management* 34(5): 882-902.

[194] Yatchew, A. (1997). An Elementary Estimator of the Partial Linear Model. *Economic Letters* 57(2): 135-143.

Curriculum Vitae

Roger Smeets was born in 1981 in Schimmert, the Netherlands. He obtained his BA in economics from the Radboud University Nijmegen in 2002. For his MA in economics he spent six months in the United States at the Virginia Polytechnic Institute and State University (Virginia Tech). He also did an internship at the Dutch Ministry of Economic Affairs, after which he completed his MA in economics at the Radboud University Nijmegen (*cum laude*) in 2004. In that year he started his PhD in economics at the same university. As part of this project he also spent five months in the United States as a visting scholar at the Rutgers Business School in Newark.

Roger's work has been published or is forthcoming in various internationally recognized journals, among which the *World Bank Research Observer*, *International Business Review* and *Regional Studies*. He has presented his research at various international conferences, seminars and workshops. Roger has also received a number of acclaims and awards, among which the annual award for the best doctoral thesis proposal of the *European International Business Academy* in 2006, and a nomination for the Haynes Prize for the most promising young scholar at the *Academy of International Business* in 2008.

As of February 2009 Roger is a postdoctoral researcher at the Netherlands Bureau of Economic Policy Analysis (*Centraal Planbureau)* in The Hague, and at the department of International Economics and Business of the University of Groningen.